



**ALEXANDER
DENNIS**

31566 Railroad Canyon Road #342

Canyon Lake, California 92587

Tel: (951) 244-9429

Fax: (951) 755-0318

Procurement No: BT01-21

**Bus – Shuttle, Transit, Trams
and Other Specialty Buses**

**Section 3.1.1 Technical
Specification**

ENVIRO⁵⁰⁰

42' (12.9m) Low Height Double Deck
Transit or Commuter Bus
(North America)

Specification



Stylish, lighter, more fuel efficient and with 80 – 86 seats, the Enviro500 has a stunning new look and overall height of just 13' 6" (4.1m).

The Go-Anywhere Enviro500 is a double deck that can operate on the same routes as single decks in virtually every part of the USA and Canada.

It offers a unique combination of high capacity and comfort, ushering in a new era for urban transit or inter-urban commuter operations.



**ALEXANDER
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ENVIRO⁵⁰⁰

42' (12.9m) Low Height Double Deck
Transit or Commuter Bus
(North America)

Go-Anywhere



The new 13' 6" (4.1m) Go-Anywhere high capacity design can operate virtually anywhere in the USA or Canada.

Capacity



The ideal solution for carrying large numbers of passengers while occupying a smaller road space (around 100 passengers in a 42' model).

Space & comfort



More space than previous designs, quiet and with superb ride comfort.

Passenger's favorite



Popular with passengers thanks to panoramic views from the top deck.

Accessible



Low step and flat floor allows full access for wheelchairs.

Flexibility



Available as an urban transit or commuter bus.

CHASSIS SPECIFICATION

ENVIRO⁵⁰⁰

42' (12.8m) Low Height Double Deck
Transit or Commuter Bus
(North America)

Engine

Cummins ISL9 8.9L six cylinder turbocharged and intercooled diesel engine certified to EPA2013 emission standards.

The emissions package includes Exhaust Gas Recirculation (EGR), Variable Geometry Turbo (VGT), Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR).

Displacement: 8.9 liters.

Power: 380 PS (283 kW) @ 1900 rpm. (Option 330 PS (240 kW) @2000rpm).

Torque: 1250 lbf-ft (1696 Nm) @ 1400 rpm. (Option 1100 lbf-ft (1493 Nm) @ 1300rpm).

Gearbox

Allison B500R automatic transmission with integral retarder, interlocks and the latest fuel saving features and technologies.

Option of Voith D854.6 four speed or ZF 6AP1700B six speed automatic gearbox, both fitted with integral retarders and interlocks and fuel saving technologies.

Front Axle

ZF RL75A deep drop beam axle.

Capacity: 16538 lbs (7500 kg).

Lock angle 47° with steering tag axle.

Drive Axle

ZF AV-132 drop centre axle.

Rear axle drive ratio selected from the following ratios to match operator performance criteria: 6.2:1, 5.74:1, 5.13:1, 4.54:1.

Capacity 26460 lbs (12000 kg).

Tag (Rear) Axle

ZF RL75A deep drop beam axle.

Capacity: 16538 lbs (7500 kg).

Lock angle 10° with steering tag axle.

Suspension

Full air suspension mounted within chassis frame floor contours eliminating component intrusion into passenger saloon areas.

Front: Two 12" (305mm) air springs. Multilink location. Anti-roll bar and two double-acting dampers.

Drive: Four 10" (255mm) air springs. Multilink location. Anti-roll bar and four double-acting dampers.

Tag: Two 11" (275mm) air springs. Trailing taper leaf springs. Panhard Rod and two double acting dampers.

Features: Mechanical levelling control system with fast-kneel facility on front suspension reducing height by 31/5" (80mm).

Steering Gear

ZF 8098 integrally powered, variable ratio steering gear.

18" (457mm) two spoke steering wheel. (Option 4 spoke coach style) both with centre horn push.

Telescopic steering column and binnacle interlocked with the handbrake for safety.

ZF RAS steering system for tag axle rear steer.

Frame

All welded steel channel and box sections complete with full body integration. Chassis frame has full corrosion protection with 2 pack epoxy coating, and wax oil cavity injection.

Braking System

Electronic Braking System (EBS).

Full air operated category 1 ABS 17" (430mm) disc brakes with separate systems for front, drive and tag axle.

Park brake is air-released, spring-actuated on drive wheels.

Hand control valve.

Fitted with Wabco 500 air compressor and Wabco Supersaver 1200 air dryer.

Wheels and Tires

Tires: 305/70R22.5 Michelin X InCity Z tubeless radial.

Wheels: 8.255" x 22.5" steel spigot mounted.

Option of Alcoa Dura-Flange, or Dura-Brite wheels.

Cooling System

Nearside rear mounted electric fan cooled radiator with separate offside rear mounted electric fan cooled CAC. Fan speeds dependent on engine cooling performance. Reverse test switch for testing and cleaning radiators installed in engine compartment.

Separate coolant header tank with sight glass and nearside fill point.

Flyscreen fitted in front of radiator on access door to minimize dirt ingress and to allow speedy cleaning.

Fuel tank

Aluminum fuel tank with a usable capacity of 119 US gallons (450 liters) mounted on nearside rear with DEF tank 71/8 US gallons (27 liters) usable capacity adjacent to fuel tank.

Electrical Equipment

24 volt, single pole negative earth.

2 x 12 volt heavy duty maintenance-free batteries with 225 Amp/hour capacity. Mounted on slide-out carrier at rear offside adjacent to engine compartment.

Battery boost socket supplied.

Integrated intelligent battery guard.

1 x 500 Amp and 1 x 275 Amp Niehoff alternators.

Fast fuse and overvoltage protection.

Continental VDO Kibes multiplex system.

Instrumentation

Stylish instrument and control binnacle with all instruments clearly visible.

Color TFT screen displaying running data and intuitive On-board diagnostics.

Options

- Electronic water header tank level indicator.
- Hubodometer.
- Ferry lift.
- Spare wheel and tire.
- Posilock fuel fill systems.
- Posilock DEF fill system.
- Alloy wheels.
- Engine oil management system.
- Service (Femco) drain valves.

BODY SPECIFICATION

Legislation

The Enviro500 transit and commuter double deck vehicles are designed to meet the legislative requirements of current 'Federal Motor Vehicle Safety Standards' (FMVSS) including 'Americans with Disabilities Act 2010' (ADA) and 'Canadian Motor Vehicle Safety Standards' (CMVSS) including CAN/CSA-D435-02 (R2012) for 'Accessible Transit Buses'. Our transit and commuter double deck vehicles are also designed to meet American State and Canadian Provincial legislation where applicable.

Structure

The low weight body structure consists primarily of aluminum extrusions and shear panels with the addition of stainless steel in areas of higher stress ensuring a high body stiffness and durability whilst minimizing the vehicle mass. All of the structural members are mechanically joined ensuring ease of repair following any form of collision damage. The top deck roof and interdeck consist of single piece composite panels significantly increasing the body stiffness with a reduction in weight compared to conventional construction. The top deck roof composite has high thermal insulation properties helping to prevent condensation. The body is rigidly fixed to a fully integrated steel chassis frame optimized for low weight and high strength. Any risk of electrolytic corrosion between dissimilar metals is removed by the application of dielectric paint. The steel frame is treated with a wax injection technology prior to undersealing the completed vehicle.

Exterior Panels

Exterior aluminum side panels are flush fitting with the glazing units giving a very clean, aesthetically pleasing appearance. Care has been taken to avoid protrusions including hinges and fixing heads to prevent build up of road dirt and to make cleaning easier. Panels in higher risk of damage from curbs including side skirts and lower corner moldings are quickly and easily replaced. Corner moldings are separate from the upper panels isolating potential damage and minimizing replacement costs.

Glazing

Main body glazing is 'direct bonded' single glazed, flat toughened safety glass, tinted to reduce solar transmittance with the option for full Dual Pane 'direct bonded' glazing. Front upper saloon and lower saloon windscreens are gasket glazed for ease of replacement. All glazing including emergency opening units comply with FMVSS 205.

Doors

The entrance is fitted with a twin leaf inward swing glider door with active seals for improved sealing performance. The exit door is fitted with a twin leaf sliding plug door providing a clear exit platform. Pneumatic doors are fitted as standard. Glazed Single and Dual Pane 'quick release' panels are offered.

Interior trim

The interior comprises of wipe-clean laminates for ease of cleaning.

Optional: Soft trim.

Driver's Cab

A spacious, comfortable, quiet and ergonomically designed driver's cab giving excellent forward vision, enhanced by the use of a curved windscreen, is provided. The fully adjustable steering wheel ensures ease of reach to the operating switches.

Flooring

All products offer low entry as standard with a floor constructed from rot and fire retarded 5/8" (15mm) Finnish Birch Plywood and covered with a hard wearing fully weldable PVC floor system available in a wide range of colors and designs to suit the operator's requirements. The joints between vertical panels and the floor are radiused making cleaning much easier.

Heating and Ventilation

Thermo King air conditioning system to upper and lower decks. TK Model TDD-M1 Southern (warm climate) specification cooling with R407c refrigerant. TK Model TDD-M2 Northern (cold climate) specification cooling with R134a refrigerant. TK Model TDD-M4 can be offered as an option for operators who can use only R407c refrigerant but require a Northern (cold climate) specification. Floor level blown "warm air" heating system to upper and lower decks. (Northern cold climate spec.). Driver's area with separate warm air demisting/heating system.

Electrical System

The 24 volt electrical system is fully multiplexed, with hardware located in easy-to-access locations. The system provides intuitive On-board diagnostics via the driver's screen. Dedicated expansion locations and interfaces are provided for additional customer equipment. The chassis system wiring is integrated and routed through the body, to improve reliability and accessibility. Bulkhead connections and modular wiring improve troubleshooting and ease of repair. Driver's courtesy lighting provides well lit entry and exit. Continuous saloon lighting is provided by stylish LED strips as standard. LED lights are standard throughout the vehicle with the exception of the headlamps. The choice of both 24v and 12v exterior lighting systems are offered.

Optional: Lighting check switch to ease driver's vehicle inspection.

Destination Gear

Front, side & rear electronic LED destinations are offered as standard on all vehicles. Streetside destination and front 'Run number' signs offered as options.

Ramps

Powered ramp offered as standard. (Ricon 621SA 1:6 ramp).

Seating

The body framing allows for a choice of transit or high back reclining seating in various configurations. Up to 55 fixed 'transit type' seats in upper saloon. Up to 31 fixed type seats in lower saloon including the three 'flip-up' seats in both wheelchair compartments.

Wheelchair provision

Two forward facing wheelchair positions in main low floor with Inertia Reel retractor belt restraints (Q Straint ARM system) fully compliant with 'ADA' (Americans with Disabilities Act). OR Two rearward facing wheelchair positions in main low floor area which are fully compliant with the requirements of CAN/CSA-D435-02 (R2012).

Energy Absorbing Front and Rear Bumpers

Optional energy absorbing bumpers can be fitted at front and rear of vehicle.

Tree Guards

Tree guards fitted to front corners of upper deck.

DIMENSIONS

Overall length	42' 5 1/8" (12931mm)
Overall height	13' 6" (4115mm)
Overall width	8' 3" (2520mm)
Wheelbase	1' 1 7/8" + 4' 11" 6430mm (Inner) 1,500mm (Outer) (Drive and tag axle centers)
Front overhang	8' 1" (2478mm)
Rear overhang	8' 3" (2523mm)

WEIGHT DATA

Front axle plated weight	15652 lbs (7100kg)
Drive axle plated weight	25352 lbs (11500kg)
Tag axle plated weight	15652 lbs (7100kg)
GVWR	56656 lbs (26500kg)

ENVIRO⁵⁰⁰

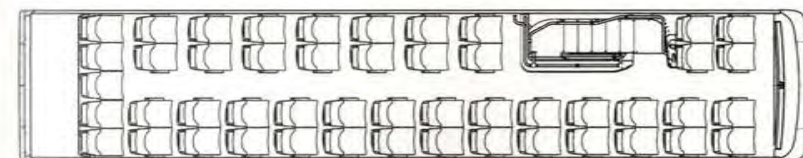
42' (12.9m) Low Height Double Deck
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(North America)



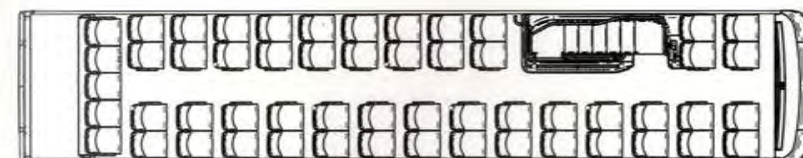
SEATING CONFIGURATIONS

42' 5" (12.9m) Two Door

Upper Saloon

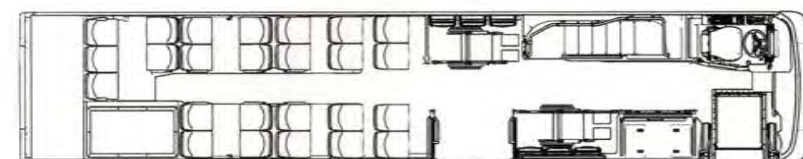


49 ♿



55 ♿

Lower Saloon



31 ♿ Or 28 ♿ + ♿ Or 25 ♿ + ♿ ♿

ENVIRO⁵⁰⁰

42' (12.9m) Low Height Double Deck
Transit or Commuter Bus
(North America)

Wide staircase



Easy to use, wide and well-lit staircase.

Cost efficient



Lowest fuel consumption per passenger carried.

Reliability



Reliable and proven engineering solutions incorporating acknowledged class-leading components.

Maintenance



Easy and low cost maintenance.

More revenue



More space for revenue generating advertisements.

Maneuverability



Simple to maneuver.

Alexander Dennis Inc.

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Canyon Lake, CA 92587-9446

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Fax: (951) 755-0318

Email: info@alexander-dennis.com

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ENVIRO500EV



Alexander Dennis is one of the world's leading bus and coach manufacturers, with a history and heritage of design, engineering and manufacturing excellence that spans more than a century. As well as producing the Enviro500 3-axle double deck bus, Alexander Dennis is renowned for manufacturing the Enviro200, a fuel efficient and maneuverable single deck bus.



ENVIRO500EV

EV battery system and capacity

Modular high voltage battery configurations dependent on range requirements

Liquid-cooled thermal management system

Integrated intelligent battery management system

Predicted range

Range figure 100-200miles depending on operational conditions and charging strategy.

Front Axle

Capacity: 17637 lbs (8000 kg). Lock angle 50°

Tag Axle

Capacity: 17637 lbs (8000 kg).

Drive Axle

Electric drive portal axle

Single or dual speed electric drive axle options available

Liquid cooled hub motors for maximum drive efficiency and control

Charging Systems

J1772 CCS1, two ports Standard, however alternative charging configurations are available

Electrical system faults are detected automatically with built-in diagnostics and interlock systems.

Suspension

Full electronic air suspension mounted within chassis frame floor contours eliminating component intrusion into passenger saloon areas.

Features: Mechanical levelling control system with fast-kneel facility on front suspension reducing height by 3" (80mm).

Steering Gear

ZF 8098 integrally powered, variable ratio steering

gear. 18" (457mm) two spoke steering wheel. (Option 4 spoke coach style) both with center horn push.

Telescopic steering column and binnacle interlocked with the handbrake for safety.

Frame

All welded steel channel and box sections complete with full body integration. Chassis frame has full corrosion protection with 2 pack epoxy coating, and wax oil cavity injection.

Braking System

Electronic Braking System (EBS).

Full air operated category 1 ABS 17" (430mm) disc brakes with separate systems for front, drive and tag axle.

Wheels

Alcoa Dura-Flange/Dura-Brite wheels.

Battery Cooling System

Rear mounted electric fan cooled radiator.

Energy efficient fan control and cooling monitoring system

Fan reverse test switch for testing and cleaning radiators installed in engine compartment.

Battery locations

Multiple high voltage battery packs integrated within the chassis frame and additional packs mounted at the rear for optimum weight distribution

Electrical Equipment

24 volt, single pole negative earth

Two compact, high capacity 12V batteries

Latest generation multiplex system with built in diagnostic & protection capabilities

Instrumentation

Stylish instrument and control binnacle with all instruments clearly visible.

Color multi-functional TFT screen displaying running data and intuitive On-board diagnostics.

Structure

The low weight body structure consists primarily of aluminum extrusions and shear panels with the addition of stainless steel in areas of higher stress ensuring a high body stiffness and durability whilst minimizing the vehicle mass. The top deck roof and interdeck consist of single piece composite panels significantly increasing the body stiffness with a reduction in weight compared to conventional construction with high thermal insulation properties.

Glazing

Main body glazing is bonded single glazed, flat toughened safety glass, tinted to reduce Solar, Light and UV transmittance with the option for full Dual Pane bonded glazing.

All glazing including emergency opening units comply with FMVSS 205.

Doors

The entrance is fitted with a twin leaf inward swing glider door with active seals for improved sealing performance. The exit door is fitted with a twin leaf sliding plug door providing a clear exit platform.

Fully Electric doors are fitted as standard.

Driver's Cab

A spacious, comfortable, quiet and ergonomically designed driver's cab giving excellent forward vision, enhanced by the use of a curved windscreen, is provided.

Heating and Ventilation

Air conditioning to upper and lower decks is provided. A floor level blown "warm air" heating system is provided to upper and lower decks.

The Driver's area has a combined warm air demisting/heating and cooling system.

Electrical System

The 24 volt electrical system is fully multiplexed, with hardware located in easy-to-access locations. The system provides intuitive on-board diagnostics via the driver's screen.

Driver's courtesy lighting provides well-lit entry and exit. Continuous saloon lighting is provided by stylish energy efficient LED strips as standard.

Full vehicle exterior LED lighting as standard for improved energy efficiency

Destination Gear

Front, side & rear electronic LED destinations are offered as standard on all vehicles.

Seating

The body framing allows for a choice of transit or high back reclining seating in various configurations. For up to 86 seated passengers + Driver. There are two ADA compliant wheelchair positions.

Dimensions

Overall length 44' 9 1/2" (13648mm)

Overall height 13' 6" (4115mm)

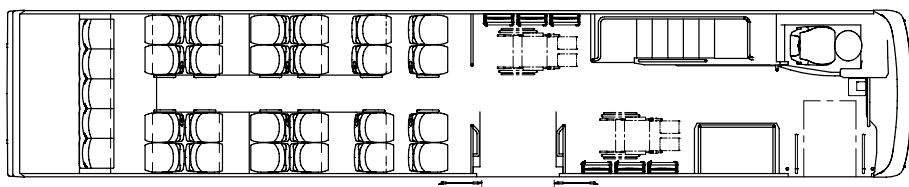
Overall width 8' 3" (2520mm)

Wheelbase 22' 5" (6830mm) +
4' 11" (Inner) 1,500mm

SEATING CONFIGURATIONS

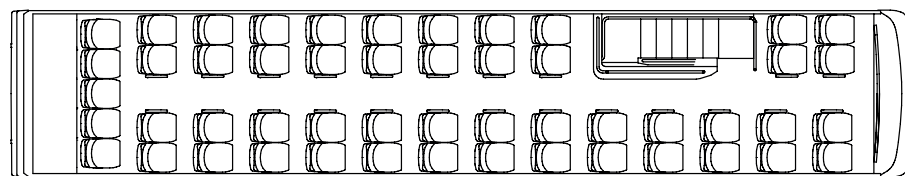
LOWER SALOON

Seating Capacity 35 or 32 Seated Plus 1 Wheelchair or 29 Seated Plus 2 Wheelchairs



UPPER SALOON

Seating Capacity 51 | All Seats ADL SmartSeat



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**Bus – Shuttle, Transit, Trams
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Section 3.1.2 Product Brochures

Bringing a new dimension
to passenger transport




**ALEXANDER
DENNIS**

ENVIRO500



Increased ridership and lower operating costs

ENVIRO⁵⁰⁰

Enviro double deck buses from Alexander Dennis are transforming transport operations across North America, increasing passenger ridership, revenue, and - in every sense - bringing a new dimension to the transport landscape of the USA and Canada.

They offer the optimum solution for high-density city transit, urban commuter and tourist routes, providing a stunning street presence and - with the same footprint as a conventional single deck bus - they are more fuel efficient, more maneuverable and capable of carrying over 100 passengers in supreme comfort.

They are 'Buy America' compliant and thanks to a new Go-Anywhere design just 13' 6" (4.1m) high, they can operate in virtually every part of the USA and Canada.

There's never been a better time to introduce Alexander Dennis double deck buses to your fleet. Where they have already gone into service, such as New York, Washington DC, Las Vegas, San Francisco, Seattle, Vancouver, Ottawa and Toronto, they have boosted ridership and revenue returns, while significantly reducing CO₂ emissions per passenger mile.

These high capacity, hugely popular buses are designed and built by Alexander Dennis, the world's leading and biggest supplier of lightweight, low emission double decks.

*The new
Go-Anywhere
double deck
can operate in
virtually every
part of the USA
and Canada.*

→ Capacity

The ideal solution for carrying large numbers of passengers while occupying a smaller road space (around 100 passengers in a 42' model).

→ Flexibility

Available as urban transit, commuter or open top tourist buses.

→ Go-Anywhere

The new 13' 6" (4.1m) Go-Anywhere high capacity design can operate virtually anywhere in the USA or Canada.

→ Maneuverability

Simple to maneuver - better than most single decks and all other high capacity options.

→ Passenger's favorite

Popular with passengers thanks to more interesting and better views from the top deck.

→ More revenue

More space for revenue generating advertisements.



→ Economic

Lower operating costs.

→ More riders

Wherever double decks have been introduced they have increased ridership.

→ Cost-efficient

Lowest fuel consumption per passenger carried.

→ Accessible

Low step and flat floor allows full access for wheelchairs, plus large volumes of seated passengers.

→ Reliability

Reliable and proven engineering solutions incorporating acknowledged class-leading components.

→ Maintenance

Easy and low cost maintenance.

→ Comfortable

More space than previous designs, quiet and with superb ride comfort.

→ Space-efficient

The same footprint as a single deck, reducing traffic congestion and costs.



→ **Go-Anywhere**
Can operate virtually anywhere in the USA and Canada.



→ **Ergonomic design**
Well positioned instruments and controls.



→ **Serviceability**
Excellent access for routine upkeep.



→ **Ease of maintenance**
Slide-out battery carrier.

Where no double deck has gone before

ENVIRO⁵⁰⁰

Stylish, lighter, more fuel efficient and with 80 – 86 seats, the new Enviro500 has a stunning modern look and overall height of just 13' 6" (4.1m).

The Go-Anywhere Enviro500 is a double deck that can operate virtually anywhere in the USA or Canada.

It offers a unique combination of high capacity and comfort, ushering in a new era for urban transit or inter-urban commuter operations. Not only is the overall height lower than previous buses, the new Enviro500 has more internal space, improving on already outstanding passenger comfort.

Equally at home as a city based transit bus or as a highly specified inter-urban commuter, Enviro500 remains as maneuverable and popular as ever and has stepped up a gear in terms of reliability, durability, low-cost maintenance and best-in-class whole life costs.

Designed exclusively for North America the Enviro500 is based on years of double deck operation across the USA and Canada.

It uses the unbeatable combination of well proven engineering and pioneering innovation that has kept Alexander Dennis at the forefront of global double deck technology.

Enviro double decks are reliable, durable, economic and easy to maintain. They use acknowledged, proven components such as Cummins engines, Allison transmissions and ZF axles.

Low cost maintenance is a hallmark of the Enviro double deck range, thanks to easy-access panels and service items that are positioned for rapid workshop turnaround.

Drivers love Enviro double decks too, with their outstanding stability, ergonomic cab design and fully adjustable driving position, plus a turning diameter that out-performs the competition.



→ Upper deck

Space and comfort plus exceptional panoramic views.



→ Stairs

Easy to use, wide and well-lit staircase.



→ Comfort

Adjustable reclining seats are one of many seating options.



→ Legroom

Every seat has ample legroom and gives the passenger a great view.

The passenger's favorite

ENVIRO⁵⁰⁰

Where Enviro double decks have been introduced - across the world - they have quickly established themselves as big favorites with passengers, thanks to their easy access, outstanding comfort and amazing panoramic views.

Now there's even more room than before with between 80 and 86 widely spaced seats, the majority in the upper saloon, all benefitting from heavy duty air conditioning.

The Enviro500 commuter option offers luxury reclining seats, individual reading lights, Wi-Fi connectivity and multimedia passenger displays amongst a whole host of passenger refinements.

Access is unbeatable with wide opening doors, plus a low step into an obstruction-free, flat floor interior. Wheelchair access is made easy too, thanks to a ramp that can be deployed and retrieved quickly, while the lower saloon provides two wheelchair spaces and seating for a further 25 passengers. Reaching the upper deck is via a wide and well-lit staircase with appropriately positioned handrails that maximize safety.

Enviro500 is equally comfortable in city center operations or cruising quietly and safely at highway speeds thanks to the advanced, full air suspension and a low center of gravity.



→ Access

A fast acting wheelchair ramp is standard.



→ Wheelchairs

A wide, step free entrance and flat floor easily accommodates wheelchairs and a further 25 seats downstairs.

Go-Anywhere



Space & comfort



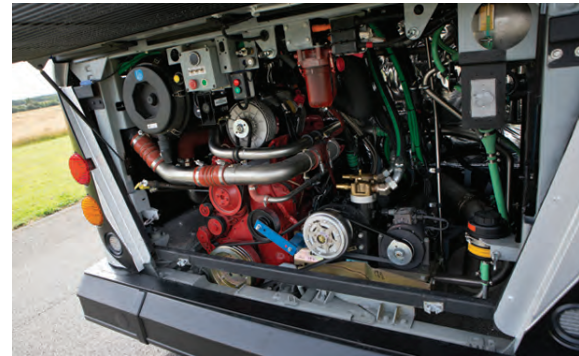
Wide staircase



More revenue



Proven components



Cost efficient

ENVIRO500

Bringing a new dimension
to passenger transport

Panoramic views



Accessible



Capacity



Maintenance



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**Bus – Shuttle, Transit, Trams
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Section 3.1.3 Altoona Report

FEDERAL TRANSIT BUS TEST

**Performed for the Federal Transit Administration U.S. DOT
In accordance with CFR 49, Volume 7, Part 665**

**Manufacturer: Alexander Dennis, Inc.
Model: E500**

**Submitted for Testing in Service-Life Category
12Year /500,000 Miles**

MAY 2015

Report Number: LTI-BT-R1411

PENNSTATE



**THE
LARSON
INSTITUTE**

**The Thomas D. Larson
Pennsylvania Transportation Institute
201 Transportation Research Building
The Pennsylvania State University
University Park, PA 16802
(814) 865-1891**

**Bus Testing and Research Center
2237 Old Route 220 North
Duncansville, PA 16635
(814) 695-3404**

FEDERAL TRANSIT BUS TEST

Performed for the Federal Transit Administration U.S. DOT
1200 New Jersey Avenue, SE
Washington, DC 20590

In accordance with CFR 49, Volume 7, Part 665

Manufacturer: Alexander Dennis Inc.
Manufacturer's address: Dennis Way, Guildford
Surrey, GU1 1AF England

Model: E500

Submitted for Testing in Service-Life Category
12 Year /500,000 Miles

Report Number: LTI-BT-R1411





Quality Authorization

Director, Bus Research
and Testing Center

Title

6/1/15

Date

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EXECUTIVE SUMMARY

Alexander Dennis, LTD., UK submitted a model E500, diesel-powered 87 seat (including the driver) 43-foot long, and 13-foot 6-inch high double decker bus, for a 12 yr./500,000 mile STURAA test. Testing started on October 16, 2014 and was completed on May 4, 2015. 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 October 16, 2014 and was completed on May 1, 2015.

The interior of the bus is configured with seating for 87 passengers including the driver. Free floor space on the lower saloon will accommodate 20 standing passengers resulting in a potential load of 107 persons. Note: the upper saloon is not designed to accommodate standing passengers. At 150 lbs. per person, this load results in a measured gross vehicle weight of 52,940 lbs. The first segment of the Structural Durability Test was performed with the bus loaded to a GVW of 52,940 lbs. The middle segment was performed at a seated load weight of 49,620 lbs. and the final segment was performed at a curb weight of 36,450 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 or Class 2 failures. Of the 35 reported failures, 20 were Class 3 and 15 were Class 4.

The Safety Test, (a double-lane change, obstacle avoidance test) was safely performed in both right-hand and left-hand directions up to a maximum test speed of 45 mph. The performance of the bus is illustrated by a speed vs. time plot. Acceleration

and gradeability test data are provided in Section 4, Performance. The average time to obtain 50 mph was 33.07 seconds. Top speed obtained on the dynamometer was 67 mph. The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 28.51' at 20 mph, 62.54' at 30 mph, 107.76' at 40 mph and 137.72' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 32.18'. 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 0.205 inches with a permanent set ranging between -0.003 to 0.004 inches under a distributed static load of 39,075 lbs. The Distortion Test was completed with all subsystems, doors and escape mechanisms operating properly. Water leakage was observed during the test at the top right corner of the windshield.

The Static Towing Test was performed using a target load (towing force) of 43,740 lbs. The 20° upward and 20° downward pulls were completed to the full target test load of 43,740 lbs. (1.2 X CW 36,450 lbs.) with no damage or deformation observed. After completion and reaching the full target test load of the 20° left pull, deformation to the left of the right side tow eye was observed. Further testing was terminated. The Dynamic Towing Test was performed by means of a front-lift tow. The towing interface was accomplished using a hydraulic under-lift wrecker. The bus was towed without incident and no damage resulted from the test. The manufacturer does not recommend towing the bus from the rear, therefore, a rear test was not performed. The Jacking and Hoisting Tests were also performed without incident. The bus was found to be stable on the jack stands, and the minimum jacking clearance observed with a tire deflated was 3.4 inches.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. The results were 2.87 mpg, 3.16 mpg, and 5.79 mpg respectively; with an overall average of 3.46 mpg.

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

The Emissions Test was performed. These results are available in Section 8 of this report.

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
PSTT	- Penn State Test Track
PTI	- Pennsylvania Transportation Institute
rpm	- revolutions per minute
SAE	- Society of Automotive Engineers
SCH	- test scheduler
SA	- staff assistant
SLW	- seated load weight (curb weight plus 150 lb for every designed passenger seating position and for the driver)
STURAA	- Surface Transportation and Uniform Relocation Assistance Act
TD	- test driver
TECH	- test technician
TM	- track manager
TP	- test personnel

TEST BUS CHECK-IN

I. OBJECTIVE

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

II. TEST DESCRIPTION

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

III. DISCUSSION

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

The test bus consists of an Alexander Dennis, Inc. Model E500. The test bus has a front door equipped with a Ricon model R16215A fold-out handicap ramp and is located forward of the front axle. The rear door is centered between the axles and the stairway to the upper saloon is rear of the driver's area. Power is provided by a diesel-fueled, Cummins model ISL9 380 engine coupled to an Allison model B500 transmission.

The measured curb weight is 9,410 lbs. for the front axle, 16,010 lbs. for the rear axle and 11,030 lbs. for the tag axle. These combined weights provide a total measured curb weight of 36,450 lbs. There are 87 seats including the driver and room for 20 standing passengers in the lower saloon bringing the total passenger capacity to 107. Note: the upper saloon is not designed to accommodate standing passengers. Gross load is $150 \text{ lb.} \times 107 = 16,050 \text{ lbs.}$ At full capacity, the measured gross vehicle weight is 52,940 lbs.

VEHICLE DATA FORM

Page 1 of 7

Bus Number: 1411	Date: 01/21/15
Bus Manufacturer: Alexander Dennis LTD, UK	Vehicle Identification Number (VIN): SFET9K748EGN13484
Model Number: E500	Chassis Mfr./Mod.#: Alexander Dennis / E500 USA Standard
Personnel: T.S., E.D. & S.R.	

WEIGHT:

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Curb	Street	Curb	Street	Curb	Street
CW	4,400	5,010	7,840	8,170	5,650	5,380
SLW	6,080	7,670	10,950	10,320	7,570	7,030
GVW	7,320	8,370	11,150	10,960	7,780	7,360

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	9,410	13,750	15,690	15,652
Middle Axle	16,010	21,270	22,110	25,353
Rear Axle	11,030	14,600	15,140	15,652
Total	36,450	49,620	52,940	GVWR: 56,659

Dimensions:

Length (ft/in)	43/5.5
Width (in)	99.75
Height (in)	162.0
Front Overhang (in)	104.5
Rear Overhang (in)	105.5
Wheel Base (in)	Front to middle axle: 252.5 Middle to rear axle: 59
Wheel Track (in)	Front: 85
	Rear: 74.9
	Tag: 83.7

VEHICLE DATA FORM

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Bus Number: 1411	Date: 01/21/15
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CLEARANCES:

Lowest Point Outside Front Axle	Location: Frame	Clearance(in): 6.5
Lowest Point Outside Rear Axle	Location: Exhaust pipe	Clearance(in): 6.9
Lowest Point between Axles	Location: Frame	Clearance(in): 8.3
Ground Clearance at the center (in)	9.1	
Front Approach Angle (deg)	6.9	
Rear Approach Angle (deg)	7.6	
Ramp Clearance Angle (deg)	4.1	
Aisle Width (in)	Lower: 19.9	Upper: 23.9
Inside Standing Height at Center Aisle (in)	Lower Front: 77.9	Lower Rear: 69.2 Upper Level: 66.2

BODY DETAILS:

Body Structural Type	Semi Monocoque		
Frame Material	Steel		
Body Material	Aluminum		
Floor Material	Plywood		
Roof Material	Fiberglass		
Windows Type	<input checked="" type="checkbox"/> Fixed	<input type="checkbox"/> Movable	
Window Mfg./Model No.	Tuf iG IND. / DOT-683 AS-3-MII		
Number of Doors	<u>1</u> Front	<u>1</u> Rear	
Mfr. / Model No.	Front: Vapor / Twin Inward Gliding Rear: Vapor / Twin Outward Sliding Plug		
Dimension of Each Door (in)	Front: 37.0 x 70.9	Rear: 41.2 x 73.6	
Passenger Seat Type	<input type="checkbox"/> Cantilever	<input checked="" type="checkbox"/> Pedestal	<input type="checkbox"/> Other (explain)
Driver Seat Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	USSC / Ser# 248044		
Number of Seats (including Driver)	87 or 81 & 2 w/c positions		

VEHICLE DATA FORM

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Bus Number: 1411	Date: 01/21/15
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BODY DETAILS (Contd..)

Free Floor Space (ft ²)	79.4
Height of Each Step at Normal Position (in)	Front 1. <u>13.7</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u> Middle 1. <u>13.5</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u> Rear 1. <u>N/A</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u>
Step Elevation Change - Kneeling (in)	3.0

ENGINE

Type	<input checked="" type="checkbox"/> C.I.	<input type="checkbox"/> Alternate Fuel	
	<input type="checkbox"/> S.I.	<input type="checkbox"/> Other (explain)	
Mfr. / Model No.	Cummins / ISL9 380		
Location	<input type="checkbox"/> Front	<input checked="" type="checkbox"/> Rear	<input type="checkbox"/> Other (explain)
Fuel Type	<input type="checkbox"/> Gasoline	<input type="checkbox"/> CNG	<input type="checkbox"/> Methanol
	<input checked="" type="checkbox"/> Diesel	<input type="checkbox"/> LNG	<input type="checkbox"/> Other (explain)
Fuel Induction Type	<input checked="" type="checkbox"/> Injected	<input type="checkbox"/> Carburetion	
Maximum Rated Output (Volts / Amps)	Engine: 28/500 A/C System: 28/225		
Air Compressor Mfr. / Model No.	Wabco / 5286681		
Maximum Capacity (ft ³ / min)	30.4		
Starter Type	<input checked="" type="checkbox"/> Electrical	<input type="checkbox"/> Pneumatic	<input type="checkbox"/> Other (explain)
Starter Mfr. / Model No.	Delco Remy / 8200833 35MT		

VEHICLE DATA FORM

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Bus Number: 1411	Date: 01/21/15
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TRANSMISSION

Transmission Type	<input type="checkbox"/> Manual	<input checked="" type="checkbox"/> Automatic	<input type="checkbox"/> Load Sensing Adaptive
Mfr. / Model No.	Allison / B500		
Control Type	<input type="checkbox"/> Mechanical	<input checked="" type="checkbox"/> Electrical	<input type="checkbox"/> Other
Integral Retarder	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	

SUSPENSION

Number of Axles	3		
Front Axle Type	<input type="checkbox"/> Independent	<input checked="" type="checkbox"/> Beam Axle	
Mfr. / Model No.	ZF / RL 75A		
Axle Ratio (if driven)	N/A		
Suspension Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	KONI / 902452657144		
Middle Axle Type	<input type="checkbox"/> Independent	<input checked="" type="checkbox"/> Beam Axle	
Mfr. / Model No.	ZF / AV 132 11-90		
Axle Ratio (if driven)	5.13		
Suspension Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	4		
Mfr. / Model No.	KONI / 902453657-145		
Rear Axle Type	<input type="checkbox"/> Independent	<input checked="" type="checkbox"/> Beam Axle	
Mfr. / Model No.	ZF / RL 75A		
Axle Ratio (if driven)	N/A		
Suspension Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	KONI / 902454657146		

VEHICLE DATA FORM

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Bus Number: 1411	Date: 01/21/15
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WHEELS & TIRES

Front	Wheel Mfr./ Model No.	ALCOA / 22.5 x 8.25
	Tire Mfr./ Model No.	Michelin XZU 305/70R22.5
Middle	Wheel Mfr./ Model No.	ALCOA / 22.5 x 8.25
	Tire Mfr./ Model No.	Michelin XZU 305/70R22.5
Rear	Wheel Mfr./ Model No.	ALCOA / 22.5 x 8.25
	Tire Mfr./ Model No.	Michelin XZU 305/70R22.5

BRAKES

Front Axle Brakes Type	<input type="checkbox"/> Cam	<input checked="" type="checkbox"/> Disc	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Knorr Bremse / SN7211		
Rear Axle Brakes Type	<input type="checkbox"/> Cam	<input checked="" type="checkbox"/> Disc	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Knorr Bremse / SB7451		
Tag Axle Brakes Type	<input type="checkbox"/> Cam	<input checked="" type="checkbox"/> Disc	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Knorr Bremse / SN7211		

HVAC

Heating System Type	<input type="checkbox"/> Air	<input checked="" type="checkbox"/> Water	<input type="checkbox"/> Other
Capacity (Btu/hr)	61,500		
Mfr. / Model No.	ThermoKing / TDD-M2 (Integrated in A/C)		
Air Conditioner	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	
Location	Rear		
Capacity (Btu/hr)	23,900		
A/C Compressor Mfr. / Model No.	ThermoKing Corporation / 1E28412G03		

STEERING

Steering Gear Box Type	Hydraulic gear		
Mfr. / Model No.	ZF / Series 8098		
Steering Wheel Diameter	18.0"		
Number of turns (lock to lock)	6 1/2		
Control Type	<input type="checkbox"/> Electric	<input checked="" type="checkbox"/> Hydraulic	<input type="checkbox"/> Other (explain)

VEHICLE DATA FORM

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Bus Number: 1411	Date: 01/21/15
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OTHERS

Wheel Chair Ramps	Location: Front	Type: Fold out
Wheel Chair Lifts	Location: N/A	Type: N/A
Mfr. / Model No.	Ricon / R16215A	
Emergency Exit	Location: Windows Doors Hatches	Number: 8 2 1

CAPACITIES

Fuel Tank Capacity (gallons)	118.0
Engine Crankcase Capacity (gallons)	6.0
Transmission Capacity (gallons)	9.3
Differential Capacity (gallons)	5.0
Cooling System Capacity (gallons)	21.5
Power Steering Fluid Capacity (gallons)	4.2

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Date: 01/21/15

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

[illegible]

COMPONENT/SUBSYSTEM INSPECTION FORM

Page 1 of 1

Bus Number: 1411	Date: 01/21/15
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Subsystem	Checked	Initials	Comments
Air Conditioning Heating and Ventilation	✓	T.S.	
Body and Sheet Metal	✓	T.S.	
Frame	✓	T.S.	
Steering	✓	T.S.	
Suspension	✓	T.S.	
Interior/Seating	✓	T.S.	
Axles	✓	T.S.	
Brakes	✓	T.S.	
Tires/Wheels	✓	T.S.	
Exhaust	✓	T.S.	
Fuel System	✓	T.S.	
Power Plant	✓	T.S.	
Accessories	✓	T.S.	
Lift System	✓	T.S.	
Interior Fasteners	✓	T.S.	
Batteries	✓	T.S.	

CHECK - IN



ALEXANDER DENNIS MODEL E500



CHECK - IN CONT.



**ALEXANDER DENNIS MODEL E500
EQUIPPED WITH A RICON MODEL
R16215A HANDICAP RAMP**



CHECK - IN CONT.



OPERATOR'S AREA



ENGINE COMPARTMENT

CHECK - IN CONT.



INTERIOR LOWER SALOON



STAIRCASE TO UPPER SALOON FROM LOWER SALOON

CHECK - IN CONT.



STAIRCASE VIEW FROM UPPER SALOON TO LOWER SALOON



INTERIOR UPPER SALOON

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

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Bus Number: 1411	Date: 4-23-15
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Component	Checked	Comments
ENGINE :		
Oil Dipstick	E.D.	
Oil Filler Hole	E.D.	
Oil Drain Plug	E.D.	
Oil Filter	E.D.	
Fuel Filter	E.D.	
Air Filter	E.D.	
Belts	E.D.	
Coolant Level	E.D.	
Coolant Filler Hole	E.D.	
Coolant Drain	E.D.	
Spark / Glow Plugs	E.D.	
Alternator	E.D.	
Diagnostic Interface Connector	E.D.	
TRANSMISSION :		
Fluid Dip-Stick	E.D.	
Filler Hole	E.D.	
Drain Plug	E.D.	
SUSPENSION :	E.D.	
Bushings	E.D.	
Shock Absorbers	E.D.	
Air Springs	E.D.	
Leveling Valves	E.D.	
Grease Fittings	E.D.	

ACCESSIBILITY DATA FORM

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Bus Number: 1411	Date: 4-23-15
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Component	Checked	Comments
HVAC :		
A/C Compressor	E.D.	
Filters	E.D.	
Fans	E.D.	
ELECTRICAL SYSTEM :		
Fuses	E.D.	
Batteries	E.D.	
Voltage regulator	E.D.	
Voltage Converters	E.D.	
Lighting	E.D.	
MISCELLANEOUS :		
Brakes	E.D.	
Handicap Lifts/Ramps	E.D.	
Instruments	E.D.	
Axles	E.D.	
Exhaust	E.D.	
Fuel System	E.D.	
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.

(Page 1 of 2)
SCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
10-31-14	1,127	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
11-12-14	2,731	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
11-24-14	4,218	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
12-03-14	5,435	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
12-09-14	6,223	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
12-17-14	7,479	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
01-07-15	8,756	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
01-13-15	9,216	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00

(Page 2 of 2)
SCHEDULED MAINTENANCE
 Alexander Dennis #1411

	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
01-19-15	10,231	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
02-25-15	11,116	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
03-16-15	12,457	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
03-25-15	13,003	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
04-01-15	14,239	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
04-27-15	15,000	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:

<u>ITEM</u>	<u>PRODUCT CODE</u>	<u>TEXACO DESCRIPTION</u>
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.

	<u>MAN HOURS</u>
ECM.	1.00
Front sway bar bushings.	3.00
8 DPF exhaust hanger isolators.	3.00
Transmission fluid line.	2.00
Left front air bag.	1.00
Tag axle centering cylinder.	4.00
Front sway bar link bushings.	2.00
Radius rod.	4.00
Air pressure sensor.	2.00
4 exhaust mount bushings.	8.00
Both front air bags.	4.00
Left front sway bar clamp & bolts.	6.00
Fan controller.	4.00
Radiator.	3.00
NOx sensor.	4.00
Left tag axle tire.	2.00
Cam sensor.	2.00

At the end of the test, the remaining items on the list were removed and replaced. The transmission assembly took 18.00 man-hours (two men 9.00 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

Page 1 of 1

Subsystem	Replacement Time
Transmission	18.00 man hours
Wiper Motor	1.00 man hours
Starter	0.50 man hours
Alternator	1.00 man hours
Batteries	1.00 man hours

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS



TRANSMISSION REMOVAL AND REPLACEMENT (18.00 MAN HOURS)



WIPER MOTOR REMOVAL AND REPLACEMENT (1.00 MAN HOUR)

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS CONT.



STARTER REMOVAL AND REPLACEMENT (0.50 MAN HOURS)



ALTERNATOR REMOVAL AND REPLACEMENT (1.00 MAN HOUR)

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

2-I. TEST OBJECTIVE

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

2-II. TEST DESCRIPTION

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

CLASS OF FAILURES

Classes of failures are described below:

- (a) Class 1: Physical Safety. A failure that could lead directly to passenger or driver injury and represents a severe crash situation.
- (b) Class 2: Road Call. A failure resulting in an en route interruption of revenue service. Service is discontinued until the bus is replaced or repaired at the point of failure.
- (c) Class 3: Bus Change. A failure that requires removal of the bus from service during its assignments. The bus is operable to a rendezvous point with a replacement bus.
- (d) Class 4: Bad Order. A failure that does not require removal of the bus from service during its assignments but does degrade coach operation. The failure shall be reported by driver, inspector, or hostler.

2-III. DISCUSSION

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

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

The classification of repairs according to subsystem is intended to emphasize those systems which had persistent minor or more serious problems. There were no Class 1 or 2 failures. Of the 20 Class 3 failures, six involved the engine/transmission, five occurred with the suspension system, two each with the steering, handicap device/doors and the electrical system and one each with the fuel system, frame structure and tires. These, and the remaining 15 Class 4 failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

RELIABILITY DATA FORM

Page 1 of 2

Bus Number:1411				Date Completed: 05-01-15		
Personal: B.R.						
	Failure Type					
	Class 4 Bad order	Class 3 Bus Change	Class 2 Road Call	Class 1 Physical Safety		
Subsystem	Mileage	Mileage	Mileage	Mileage	Man hours	Down Time
Suspension		1,281			6.00	6.00
	4,869				3.00	3.00
	6,120				2.00	2.00
		6,312			1.00	1.00
	7,399				2.00	2.00
	8,756				6.00	6.00
	8,756				4.00	4.00
	8,756				4.00	4.00
	10,231				4.00	4.00
		10,231			6.00	6.00
	11,117				2.00	2.00
	12,457				2.00	2.00
		14,239			14.00	34.00
		14239			4.00	4.00
	Engine/ Transmission		4,869			2.00
		10,231			2.00	2.00
		10,879			4.00	111.00
		10,879			3.00	207.00
		12,244			4.00	68.00
		12,457			2.00	16.00
Electrical		2,900			1.00	24.00
	11,117				0.25	0.25
		12,244			5.00	5.00
Handicap device/ Doors		8,518			9.00	208.00
	8,756				2.00	56.00
		13,190			2.00	2.00

RELIABILITY DATA FORM
Page 2 of 2

Bus Number: 1411				Date Completed: 05-01-15		
Personal: B.R.						

	Failure Type					
	Class 4 Bad order	Class 3 Bus Change	Class 2 Road Call	Class 1 Physical Safety		
Subsystem	Mileage	Mileage	Mileage	Mileage	Man hours	Down Time
Steering		4,869			3.00	32.00
		6,312			4.00	16.00
	7,399				2.00	6.00
Fuel System		289			4.00	16.00
	4,869				3.00	3.00
Air System	8,756				2.00	2.00
Exhaust System	8,756				8.00	8.00
Frame Structure		10,231			8.00	104.00
Wheels/Tires		12,435			2.00	4.00

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

Page 1 of 1

Bus Number: 1411	Date: 4-16-15
Personnel: S.R., E.D. & M.H.	

Temperature (°F): 61	Humidity (%): 28
Wind Direction: S	Wind Speed (mph): 7
Barometric Pressure (in.Hg): 30.36	

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 33.07 seconds. Maximum speed obtained on the dynamometer was 67 mph.

PERFORMANCE DATA FORM

Page 1 of 1

Bus Number: 1411		Date: 4-16-15	
Personnel: S.R., E.D. & M.H.			
Temperature (°F): 63		Humidity (%): 25	
Wind Direction: SSE		Wind Speed (mph): 11	
Barometric Pressure (in.Hg): 30.37			
			INITIALS:
Air Conditioning - OFF	✓Checked	S.R.	
Ventilation fans - ON HIGH	✓Checked	S.R.	
Heater pump motor - OFF	✓Checked	S.R.	
Defroster - OFF	✓ Checked	S.R.	
Exterior and interior lights - ON	✓ Checked	S.R.	
Windows and doors - CLOSED	✓ Checked	S.R.	
ACCELERATION, GRADEABILITY, TOP SPEED			
Counter Clockwise Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph	3.32	3.75	3.70
20 mph	6.90	6.95	6.80
30 mph	11.79	11.54	11.43
40 mph	19.26	19.38	18.95
Top Test Speed(mph) 50	33.04	33.49	32.67
Clockwise Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph	3.78	4.27	3.63
20 mph	8.42	8.39	6.50
30 mph	12.94	13.27	10.72
40 mph	21.50	19.83	17.87
Top Test Speed(mph) 50	33.01	33.59	32.64

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :Alexander Dennis
 BUS MODEL :E500
 BUS NUMBER :1411
 TEST DATE :04/06/2015

TEST CONDITIONS :

 TEMPERATURE (DEG F) : 63.0
 WIND DIRECTION : SSE
 WIND SPEED (MPH) : 11.0
 HUMIDITY (%) : 25
 BAROMETRIC PRESSURE (IN. HG) : 30.4

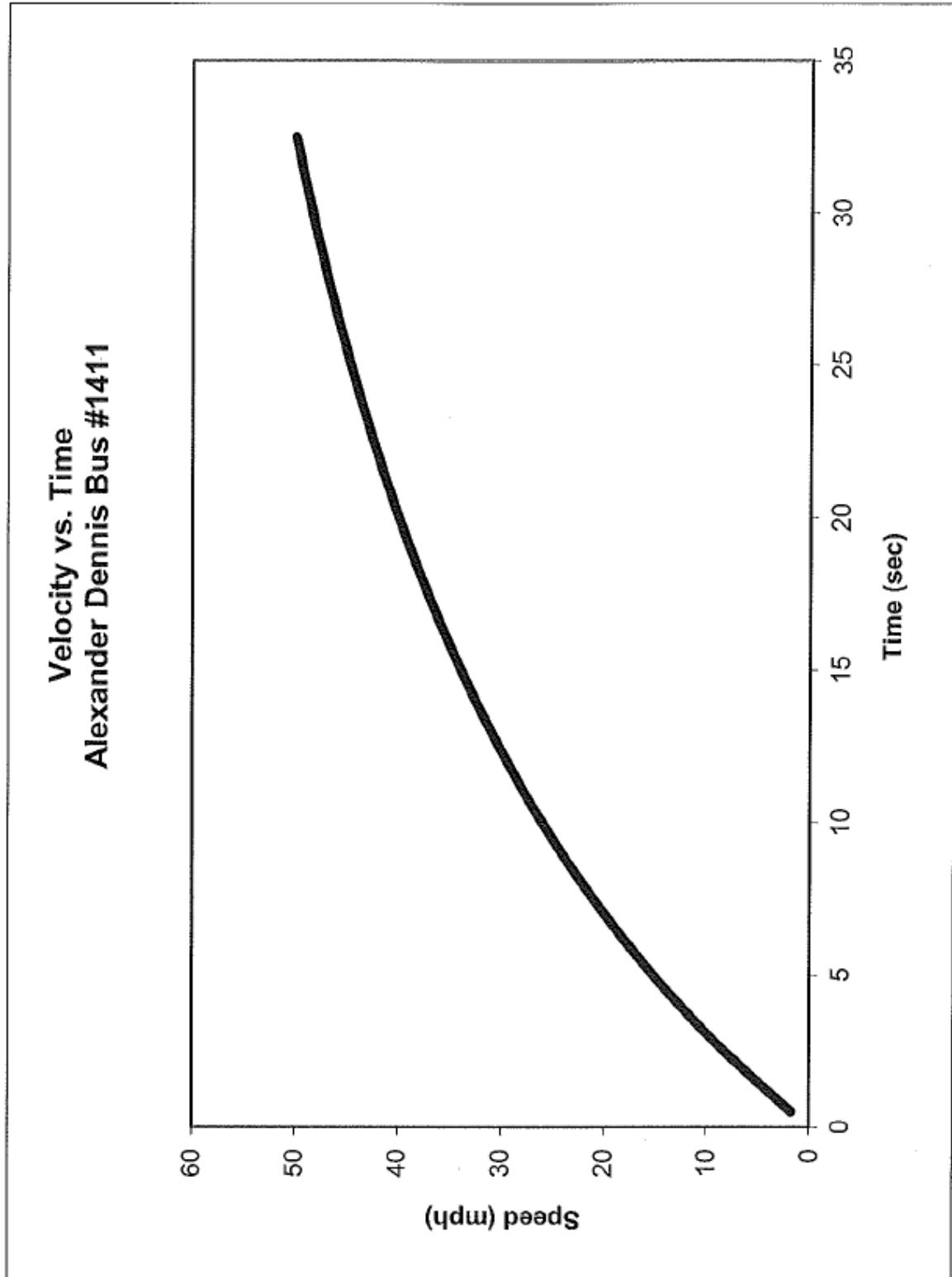
(MPH)	AVERAGE TIME (SEC)		
	CCW DIRECTION	CW DIRECTION	TOTAL
10.0	3.59	3.89	3.74
20.0	6.88	7.77	7.33
30.0	11.59	12.31	11.95
40.0	19.20	19.73	19.47
50.0	33.07	33.08	33.07

TEST SUMMARY :

VEHICLE SPEED (MPH)	TIME (SEC)	ACCELERATION (FT/SEC^2)	MAX. GRADE (%)
1.0	.28	5.2	16.4
5.0	1.45	4.8	15.0
10.0	3.08	4.2	13.3
15.0	4.92	3.7	11.7
20.0	7.03	3.2	10.1
25.0	9.48	2.8	8.6
30.0	12.37	2.3	7.2
35.0	15.84	1.9	6.0
40.0	20.11	1.5	4.8
45.0	25.51	1.2	3.7
50.0	32.61	.9	2.8

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 Curve



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 28.51' at 20 mph, 62.54' at 30 mph, 107.76' at 40 mph and 137.72' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 32.18'. 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

Page 1 of 3

Bus Number: 1411	Date: 4-15-15
Personnel: S.R., E.D. & T.G.	
Amb. Temperature (°F): 58	Wind Speed (mph): 9
Wind Direction: NNE	Pavement Temp (°F) Start: 76.8 End: 83.4

TIRE INFLATION PRESSURE (psi):				
Tire Type: Front: Michelin XZU 305/70R 22.5			Rear: Michelin XZU 305/70R 22.5	
	Left Tire(s)		Right Tire(s)	
Front	125		125	
	Inner	Outer	Inner	Outer
Rear	110	110	110	110
Rear	N/A	125	N/A	125

AXLE LOADS (lb)		
	Left	Right
Front	8,370	7,320
Rear	10,960	11,150
Rear	7,360	7,780

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

Page 2 of 3

Date	Personnel	Fault/Repair	Description
4-15-15	S.R., E.D. T.G.	None noted.	None noted.

Table 4.2-8.1. Stopping Distance Test Results Form

Page 3 of 3

Stopping Distance (ft)					
Vehicle Direction	CW	CW	CCW	CCW	
Speed (mph)	Stop 1	Stop 2	Stop 3	Stop 4	Average
20 (dry)	30.12	29.62	28.12	26.16	28.51
30 (dry)	61.46	58.10	70.91	59.67	62.54
40 (dry)	107.63	111.25	106.23	105.90	107.76
45 (dry)	135.78	134.20	143.24	137.63	137.72
20 (wet)	32.69	31.25	30.86	33.92	32.18

Table 4.2-8.2. Stability Test Results Form

Stability Test Results (Split Friction Road surface)			
Vehicle Direction	Attempt	Did test bus stay in 12' lane? (yes/no)	Comments
Drivers side on high friction	1	Yes	None noted.
	2	Yes	None noted.
Drivers side on low friction	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	5:00			X	
	2					
	3					
Front down	1	5:00			X	
	2					
	3					

4.2 Performance - Bus Braking



20% DOWNWARD GRADE



20% UPWARD GRADE

5.1 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 101 people including the driver plus 2 wheelchair positions. The resulting test load is $(101 \times 375 \text{ lbs.}) = 37,875 \text{ lbs.} + 1,200 \text{ lbs. (2 wheelchair positions)} = 39,075 \text{ lbs.}$ 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 0.205 Inches at reference point 10. The maximum permanent deflection after the final loading sequence ranged from -0.003 Inches at reference points 1 and 6 to 0.004 inches at reference points 3, 4, 9 and 10.

STRUCTURAL SHAKEDOWN DATA FORM

Page 1 of 2

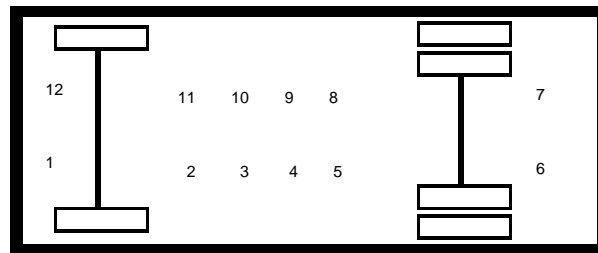
Bus Number: 1411	Date: 4-6-15
Personnel: E.D., T.G. & P.D.	Temperature (°F): 65
Loading Sequence: <input checked="" type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 (check one) Test Load (lbs.): 39,075 (81 seated, 20 standees, 2 W/C)	

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	-.009	-.009	-.011	-.011
2	0	.116	.116	.021	.021
3	0	.206	.206	.043	.043
4	0	.181	.181	.023	.023
5	0	.121	.121	.013	.013
6	0	.030	.030	-.006	-.006
7	0	.062	.062	.009	.009
8	0	.149	.149	.022	.022
9	0	.210	.210	.029	.029
10	0	.224	.224	.033	.033
11	0	.145	.145	.023	.023
12	0	-.010	-.010	-.021	-.021

STRUCTURAL SHAKEDOWN DATA FORM

Page 2 of 2

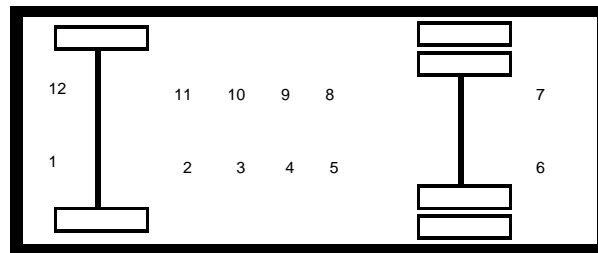
Bus Number: 1411	Date: 4-8-15
Personnel: E.D., T.G. & P.D.	Temperature (°F): 60
Loading Sequence: <input type="checkbox"/> 1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 (check one) Test Load (lbs.): 39,075 (81 seated, 20 standees, 2 W/C)	

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	-.011	-.022	-.011	-.014	-.003
2	.021	.130	.109	.023	.002
3	.043	.224	.181	.047	.004
4	.023	.181	.158	.027	.004
5	.013	.118	.105	.015	.002
6	-.006	.020	.026	-.009	-.003
7	.009	.057	.048	.011	.002
8	.022	.151	.129	.025	.003
9	.029	.213	.184	.033	.004
10	.033	.238	.205	.037	.004
11	.023	.165	.142	.026	.003
12	-.021	-.024	-.003	-.023	-.002

5.1 STRUCTURAL SHAKEDOWN TEST



DIAL INDICATORS IN POSITION



**BUS LOADED TO 2.5 TIMES GVL
(39,075 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 14 times. The first and last test is with all wheels level. The other twelve 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. Water leakage was observed during the test at the top right corner of the windshield. 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)

Page 1 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input checked="" type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 2 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 3 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 4 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 5 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 6 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in higher
Right tag	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 7 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 8 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 9 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 10 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 11 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
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Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 13 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
 (Note: Ten copies of this data sheet are required)
 Page 14 of 14

Bus Number: 1411	Date: 4-9-15
Personnel: E.D. & T.G.	Temperature(°F): 45

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input checked="" type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left tag	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 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	Windshield leaked, top right corner.
Steering Mechanism	No deficiencies.

5.2 STRUCTURAL DISTORTION TEST



RIGHT FRONT WHEEL SIX INCHES HIGHER



LEFT TAG 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 load-distributing yoke was incorporated as the interface between the Static Tow apparatus and the test bus tow hook/eyes. The 20° upward and 20° downward pulls were completed to the full target test load of 43,740 lbs. (1.2 X CW 36,450 lbs.) with no damage or deformation observed. After completion and reaching the full target test load of the 20° left pull, deformation to the left of the right side tow eye was observed. Further testing was terminated.

STATIC TOWING TEST DATA FORM

Page 1 of 1

Bus Number: 1411	Date: 5-1-15
Personnel: T.S., S.R., E.D. & E.L.	Temperature (°F): 60

Inspect right front tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: Welds inspected.
Inspect left front tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: Welds inspected.
Inspect right rear tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: N/A
Inspect left rear tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: N/A
General comments of any other structure deformation or failure: The 20° up and 20° downward pulls were completed with no damage or deformation observed. After completing the 20° left pull, the right side tow eye was observed to be bent to the left. Further testing was terminated.

5.3 STATIC TOWING TEST



FRONT 20° UPWARD PULL



FRONT 20° DOWN PULL

5.3 STATIC TOWING TEST CONT.



FRONT 20° LEFT



DEFORMATION OF LEFT TOW EYE

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

Page 1 of 1

Bus Number: 1411	Date: 3-30-15
Personnel: S.R., T.G., E.L., J.P., & P.D.	

Temperature (°F): 43	
Wind Direction: WNW	Wind Speed (mph): 18

Inspect tow equipment-bus interface.
Comments: A safe and adequate connection was made between the bus and the towing equipment.
Inspect tow equipment-wrecker interface.
Comments: A safe and adequate connection was made between the tow equipment and the wrecker.
Towing Comments: A front lift tow was performed incorporating a hydraulic under-lift wrecker.
Description and location of any structural damage: None noted.
General Comments: No problems with the towing interface or procedures were encountered.

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 jack is lowered. Any structural damage or permanent deformation is recorded on the test data sheet. This procedure is repeated for each corner of the bus.

5.5-III. DISCUSSION

The jack used for this test has a minimum height of 8.75 inches. During the deflated portion of the test, the jacking point clearances ranged from 3.4 inches to 9.1 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	6.3"
Rear axle – one tire flat	8.3"
Rear axle – two tires flat	8.3"

JACKING TEST DATA FORM

Page 1 of 1

Bus Number: 1411	Date: 01/22/15
Personnel: T.S., E.D. & S.R.	Temperature (°F): 67

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	8.8 " I 6.4 " D	6.6 " I 4.2 " D	Body/Axle
Left front	8.5 " I 6.3 " D	6.4 " I 4.4 " D	Body/Axle
Right rear—outside drive axle	8.4 " I 8.3 " D	6.8 " I 6.4 " D	Body/Suspension
Right rear—both drive axle	8.4 " I 8.3 " D	6.8 " I 4.9 " D	Body/Suspension
Left rear—outside drive axle	9.3 " I 9.1 " D	6.4 " I 5.8 " D	Body/Suspension
Left rear—both drive axle	9.3 " I 9.0 " D	6.4 " I 3.7 " D	Body/Suspension
Right tag—outside	8.8 " I 5.1 " D	6.1 " I 3.7 " D	Body/Axle
Right middle or tag—both	N/A	N/A	N/A
Left tag—outside	9.4 " I 5.5 " D	6.4 " I 3.4 " D	Body/Axle
Left middle or tag— both	N/A	N/A	N/A
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

Page 1 of 1

Bus Number: 1411	Date: 01/23/15
Personnel: T.S. & E. D.	Temperature (°F): 66

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.
Comments of any problems or interference placing wheel hoists under wheels:
When doing the second and third positions, we used 12" blocks to support the tag
axle tires because the tag axle levelling air valves control the air in the drive axle
suspension.

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 15,000 miles; approximately 12,500 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 6,250 miles with the bus operated at GVW. The second segment will consist of approximately 2,500 miles with the bus operated at SLW. The remainder of the test, approximately 6,250 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 16, 2014 and was conducted until May 1, 2015. The first 6,250 miles were performed at a GVW of 52,940 lbs. and completed on December 8, 2014. The next 2,500 mile SLW segment was performed at 49,620 lbs. and completed on December 23, 2014, and the final 6,250 mile segment was performed at a CW of 36,450 lbs. and completed on May 1, 2015.

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.

Alexander Dennis #1411

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
10/13/14 TO 10/19/14	0.00	107.00	107.00
10/20/14 TO 10/26/14	141.00	58.00	199.00
10/27/14 TO 11/02/14	732.00	89.00	821.00
11/03/14 TO 11/09/14	839.00	91.00	930.00
11/10/14 TO 11/16/14	706.00	137.00	843.00
11/17/14 TO 11/23/14	1156.00	53.00	1209.00
11/24/14 TO 11/30/14	692.00	31.00	723.00
12/01/14 TO 12/07/14	795.00	139.00	934.00
12/08/14 TO 12/14/14	821.00	297.00	1118.00
12/15/14 TO 12/21/14	948.00	138.00	1086.00
12/22/14 TO 12/28/2014	420.00	128.00	548.00
12/29/14 TO 01/04/15	0.00	0.00	0.00
01/05/15 TO 01/11/15	280.00	113.00	393.00
01/12/15 TO 01/18/15	1128.00	48.00	1176.00

Alexander Dennis #1411

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
01/19/15 TO 01/25/15	88.00	107.00	195.00
01/26/15 TO 02/01/15	320.00	14.00	334.00
02/02/15 TO 02/08/15	204.00	8.00	212.00
02/09/15 TO 02/15/15	49.00	2.00	51.00
02/16/15 TO 02/22/15	0.00	0.00	0.00
02/23/15 TO 03/01/15	581.00	129.00	710.00
03/02/15 TO 03/08/15	481.00	19.00	500.00
03/09/15 TO 03/15/15	352.00	16.00	368.00
03/16/15 TO 03/22/15	480.00	22.00	502.00
03/23/15 TO 03/29/15	565.00	52.00	617.00
03/30/15 TO 04/05/15	722.00	130.00	852.00
04/06/15 TO 04/12/15	0.00	0.00	0.00
04/03/15 TO 04/19/15	0.00	95.00	95.00
04/20/15 TO 04/26/15	0.00	178.00	178.00

Alexander Dennis #1411

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
04/27/15 TO 05/03/15	0.00	365.00	365.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
TOTAL	12500.00	2566.00	15066.00

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
Shift 2	7:50 am	F
	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
Shift 3	3:40 pm	C
	3:50 pm	F
	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

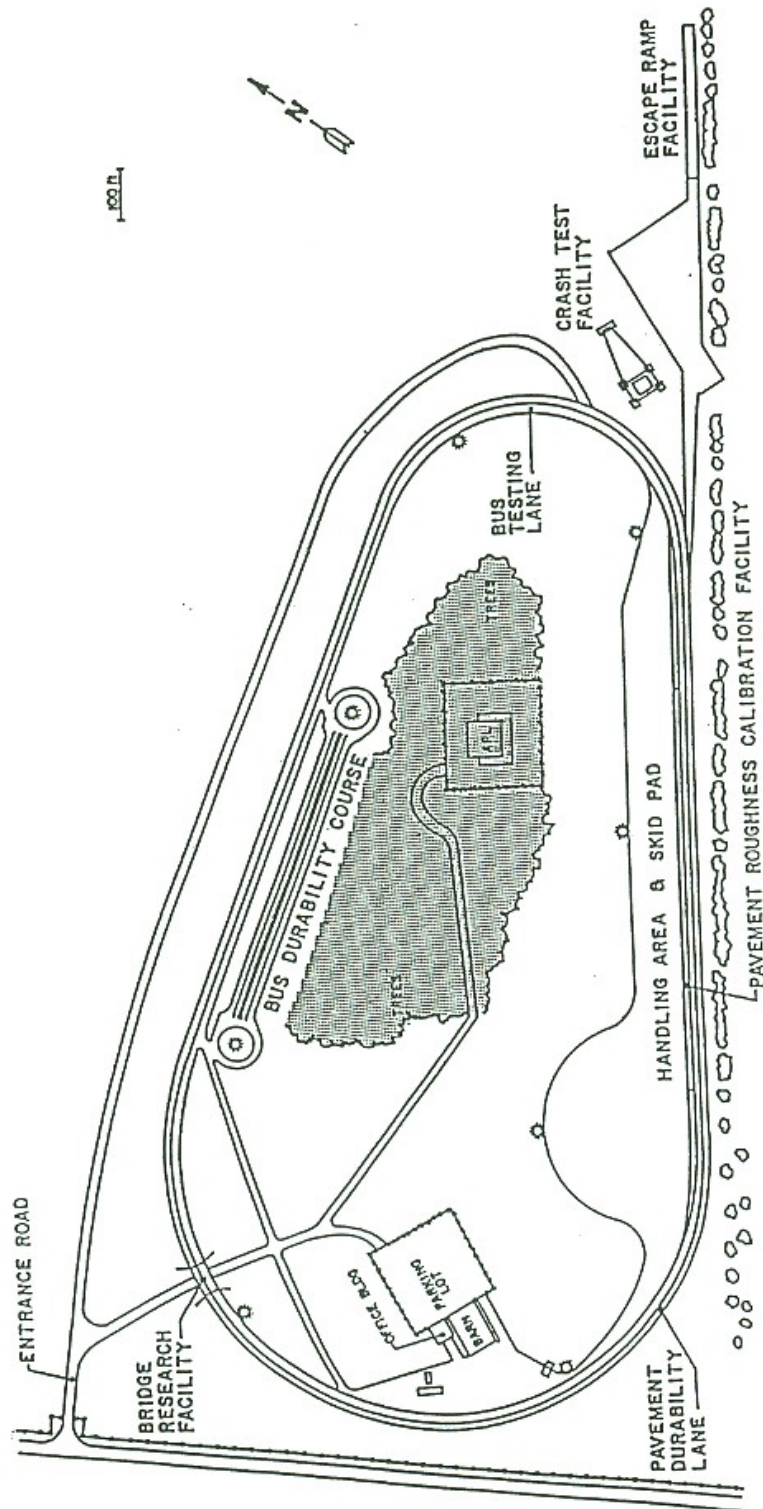
B—Break

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

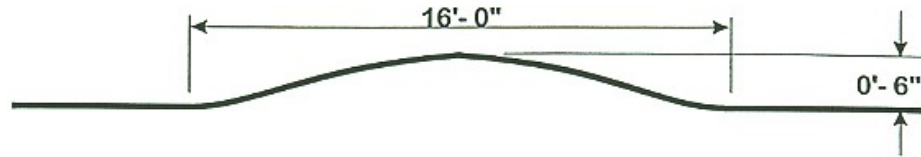
“PLAN VIEW OF PENN STATE BUS TESTING AND RESEARCH FACILITY”



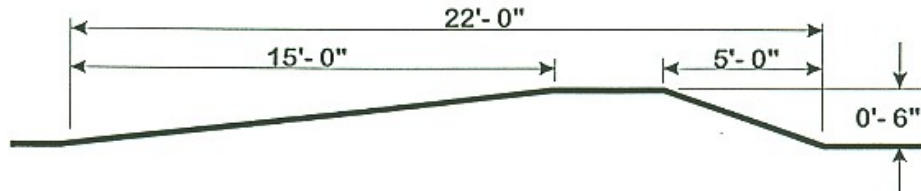
**BUS TESTING AND RESEARCH TEST TRACK
UNIVERSITY PARK, PA**



Staggered
Bumps
(10 mph)



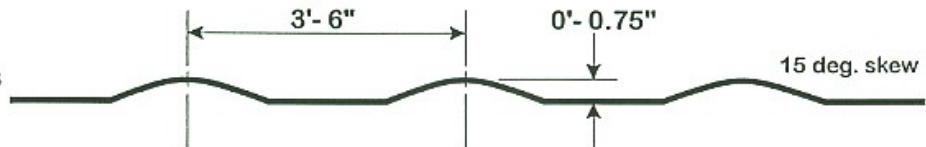
Railroad
Crossing
(8 mph)



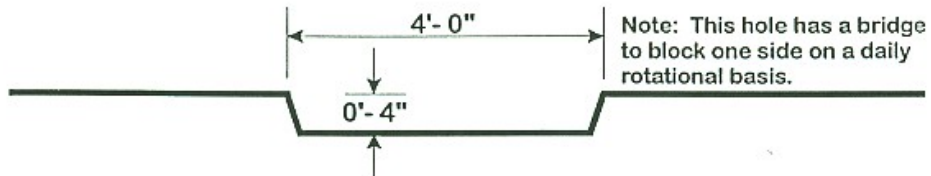
1" Random
Chuck Holes
(20 mph)



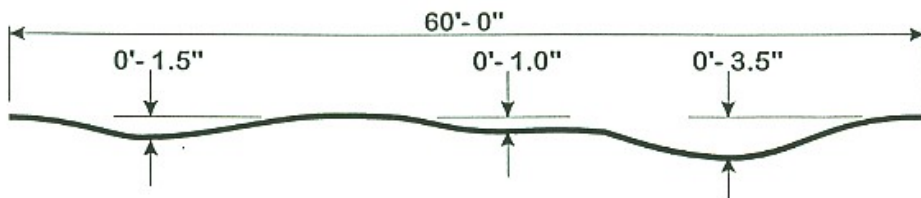
Chatter Bumps
(20 mph)



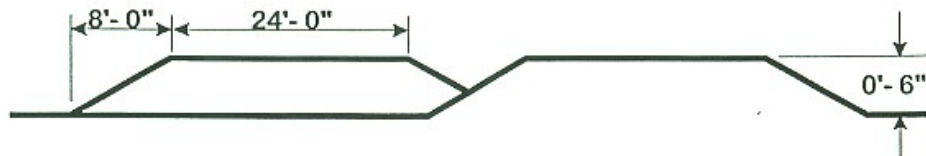
4" Chuck Hole
(5 mph)



High Crown
Intersection
(20 mph)



Frame Twist
(10 mph)



Durability Element Profiles

The Pennsylvania Transportation Institute
Penn State

(Page 1 of 6)
UNSCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
10-23-14	289	Troubleshoot DEF system for Trouble Code 1713.	Reroute DEF heater hoses, inlet and outlet lines were reversed.	4.00	16.00
11-04-14	1,281	Right side tag axle; the bolt came out of the air bag piston. The loose piston caused damage to the leveling valve and leveling valve mount.	Leveling valve mount repaired. Replaced leveling valve, air bag and piston.	6.00	6.00
11-17-14	2,900	The ECM failed.	Manufacturer's rep replaced ECM.	1.00	24.00
12-04-14	4,869	The front sway bar bushings are worn.	Front sway bar bushings replaced.	3.00	3.00
12-04-14	4,869	The steering gear accumulator bracket is broken.	Steering gear accumulator bracket welded/repared.	3.00	32.00
12-04-14	4,869	The isolators on the DPF exhaust hangers are worn.	All 8 isolators replaced.	3.00	3.00
12-04-14	4,869	The transmission fluid line at the retarder is leaking fluid.	Transmission fluid line replaced.	2.00	2.00
12-09-14	6,120	The right front sway bar bushings are worn.	Right front sway bar bushings replaced.	2.00	2.00
12-10-14	6,312	The left front air bag is leaking.	Manufacturer's rep replaced the left front air bag.	1.00	1.00

(Page 2 of 6)
UNSCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
12-10-14	6,312	Check for fluid leak in the tag axle area. Found a crack in the hydraulic hose connection port on the tag axle centering cylinder.	Replaced centering cylinder, bled air from lines and topped off fluid.	4.00	16.00
12-17-14	7,399	The front sway bar link bushings are worn.	Front sway bar link bushings replaced.	2.00	2.00
12-17-14	7,399	The tag axle hydraulic steering system has air in the lines.	Air bled from tag axle hydraulic steering system.	2.00	6.00
01-05-15	8,518	Handicap ramp will not stow.	Troubleshooting. Partially dismantled handicap ramp to get stowed. Bus moved to shop. Handicap device inoperative.	9.00	208.00
01-07-15	8,756	Both front air bags are scuffing the shocks and leveling valve arms. Manufacturer requested one of two washers be removed from the top and bottom bolts on the radius rods directly under the front air bag mounting plates (both left and right).	Work performed as requested.	6.00	6.00
01-07-15	8,756	Bushings are worn on the radius rod; inside drive axle wheel well above axle.	Radius rod replaced.	4.00	4.00

(Page 3 of 6)
UNSCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
01-07-15	8,756	The air pressure sensor switch is leaking on the left rear air tank forward of the drive axle.	Air pressure sensor replaced.	2.00	2.00
01-07-15	8,756	The front passenger door has dropped and is rubbing on the floor.	Door adjusted up to proper height.	2.00	56.00
01-08-15	8,756	The front sway bar bushings are worn.	Front sway bar bushings replaced.	4.00	4.00
01-08-15	8,756	Four exhaust mount bushings are worn.	Four exhaust mount bushings replaced.	8.00	8.00
01-19-15	10,231	Four mounting tabs are broken on the engine cooling fan box and cage.	Four engine cooling fan box and cage mounting tabs welded/repared.	2.00	2.00
01-19-15	10,231	Both front air bags are worn from contact with the shocks.	Both front air bags replaced.	4.00	4.00
01-20-15	10,231	Front sway bar; the two rearmost clamp bolts are broken and the clamp is damaged.	Left front sway bar clamp and bolts replaced.	6.00	6.00

(Page 4 of 6)
UNSCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
01-20-15	10,231	Two c-channels beneath the wheelchair ramp have broken welds.	Broken welds welded/repaired.	8.00	104.00
02-10-15	10,879	The engine cooling fans are inoperative.	Fan controller replaced and wires rearranged in the proper sockets for the new controller.	4.00	111.00
02-23-15	10,879	The radiator is split and leaking coolant.	Assisted manufacturer in replacing radiator.	3.00	207.00
02-25-15	11,117	The yellow EBS warning light, the orange triangle warning light and the orange engine symbol light (malfunction indicator) are on.	Pad-ware sensor wire pinched. Manufacturer's rep advises ok to run with warning lights on.	0.25	0.25
02-25-15	11,117	The lower right front sway bar bushings are worn.	Both lower front sway bar bushings replaced.	2.00	2.00
03-12-15	12,244	The NOx sensor has failed.	Manufacturer's rep trouble shooting. Replaced NOx sensor.	4.00	68.00

(Page 5 of 6)
UNSCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
03-12-15	12,244	Reference warning lights reported on 2/25/15.	Manufacturer's rep located and repaired pinched wires in wiring harness. Warning lights are now out and functioning properly.	5.00	5.00
03-13-15	12,435	The left tag axle tire is flat.	Left tag axle tire replaced.	2.00	4.00
03-16-15	12,457	The bushings are worn on the front sway bar.	Replaced front sway bar bushings.	2.00	2.00
03-16-15	12,457	Bus experiencing erratic engine performance. "Check Engine" light is on.	Manufacturer's rep troubleshooting found failed Cam sensor. Cam sensor replaced.	2.00	16.00
03-26-15	13,190	The front passenger door is inoperative.	Troubleshoot air & electrical circuits: found one wire broken and another damaged at connector PX 05 on the circuit board in the electrical panel. Temporary repair made with butt connectors until new pins arrive. Four of six standoffs were missing on the circuit board causing wires to break.	2.00	2.00

(Page 6 of 6)
UNSCHEDULED MAINTENANCE
 Alexander Dennis #1411

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
04-02-15	14,239	The upper shock mount is broken on the left, forward drive axle shock.	Fabricated and installed new shock mount as per manufacturer's specs. 1/4" x 3 1/2" x 14".	14.00	34.00
04-02-15	14,239	The right side clamp bolt on the front sway bar is broken, and the front sway bar link bushings are worn.	All four front sway bar clamp bolts replaced. Front sway bar link bushings replaced.	4.00	4.00

UNSCHEDULED MAINTENANCE



**BENT LEVELING VALVE MOUNT
(1,281 TEST MILES)**



**FRONT SWAY BAR BUSHINGS ARE WORN
(4,869 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**WORN RIGHT FRONT SWAY BAR BUSHING
(6,120 TEST MILES)**



**LEAKING LEFT FRONT AIR BAG
(6,312 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**CRACKED PORTS ON THE
TAG AXLE CENTERING CYLINDER
(6,312 TEST MILES)**



**WORN FRONT SWAY BAR LINK BUSHING
(7,399 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**WORN RADIUS ROD BUSHING
(8,756 TEST MILES)**



**LEAKING AIR PRESSURE SENSOR
(8,756 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**WORN FRONT SWAY BAR BUSHING
(8,756 TEST MILES)**



**WORN EXHAUST MOUNT BUSHING
(8,756 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**BROKEN ENGINE COOLING FAN BOX TAB
(10,231 TEST MILES)**



**WORN AIR BAG FROM CONTACT WITH SHOCK
(10,231 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**FRONT SWAY BAR; BROKEN CLAMP BOLTS
(10,231 TEST MILES)**



**SPLIT RADIATOR
(10,879 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.

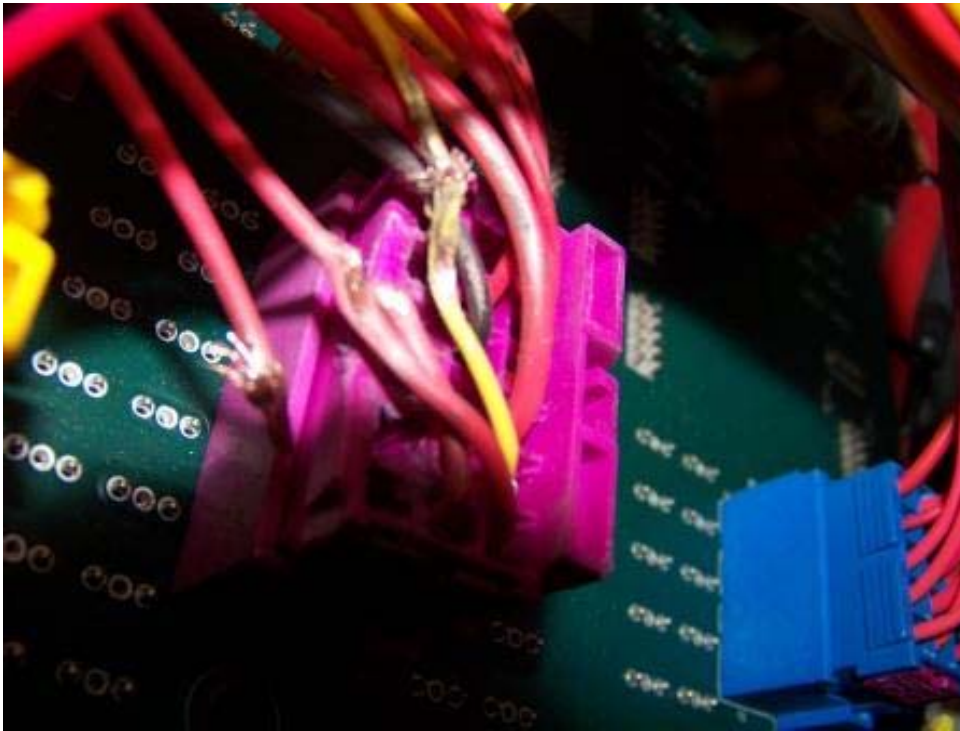


**WORN FRONT SWAY BAR BUSHINGS
(11,117 TEST MILES)**



**FAILED NOx SENSOR
(12,244 TEST MILES)**

UNSCHEDULED MAINTENANCE CONT.



**DAMAGED WIRES AT PX 05 CONNECTOR
(13,190 TEST MILES)**



**BROKEN UPPER SHOCK MOUNT
(14,239 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

$$FE_{o_{mi/lb.}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{lb of fuel}}$$

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

$$FE_{\text{mpg}} = FE_{\text{mi/lb}} \times G_s \times G_w$$

where G_s = Specific gravity of test fuel at 60°F (referred to water)
 G_w = 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.

$$FE_c = FE_{\text{mpg}} \times \frac{Q}{H}$$

where

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

Combining steps 1-3 yields

$$\Rightarrow FE_c = \frac{\text{miles}}{\text{lbs}} \times (G_s \times G_w) \times \frac{Q}{H}$$

- 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/BTUx10⁶.

Eq = Energy equivalent of converting mpg to mile/BTUx10⁶.

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

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/BTUx10⁶) 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

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

- 2.) Convert the observed fuel economy to miles per lb by dividing FEO by the density of the test fuel at standard conditions (Lb/ft³).

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.

$$FEO_{mi/lb} = FEO / G_m$$

where G_m = Density of test fuel at standard conditions

- 3.) Convert the observed fuel economy (FEO_{mi/lb}) to an energy equivalent of (miles/BTUx10⁶) by dividing the observed fuel economy (FEO_{mi/lb}) by the heating value of the test fuel at standard conditions.

$$Eq = (FEO_{mi/lb} / H) \times 10^6$$

where

Eq = Energy equivalent of miles/lb to mile/BTUx10⁶

H = Volumetric heating value of test fuel at standard conditions

6-III. DISCUSSION

This is a comparative test of fuel economy using diesel fuel with a heating value of 19,568.0 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 126,700.0 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 – 2.87 mpg, ART – 3.16 mpg, and COM – 5.79 mpg. Average fuel consumption at idle was 0.74 gph.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 1 of 3

Bus Number: 1411	Date: 4-23-15	SLW (lbs.): 49,620
Personnel: T.S., S.R. & J.S.		

FUEL SYSTEM	OK
Install fuel measurement system	S.R.
Replace fuel filter	S.R.
Check for fuel leaks	S.R.
Specify fuel type (refer to fuel analysis)	Diesel
Remarks: None noted.	
BRAKES/TIRES	OK
Inspect hoses	S.R.
Inspect brakes	S.R.
Relube wheel bearings	S.R.
Check tire inflation pressures (mfg. specs.)	S.R.
Check tire wear (less than 50%)	S.R.
Remarks: None noted.	
COOLING SYSTEM	OK
Check hoses and connections	S.R.
Check system for coolant leaks	S.R.
Remarks: None noted.	

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 2 of 3

Bus Number: 1411	Date: 4-22-15
Personnel: T.S., SR. & J.S.	
ELECTRICAL SYSTEMS	OK
Check battery	S.R.
Inspect wiring	S.R.
Inspect terminals	S.R.
Check lighting	S.R.
Remarks: None noted.	
DRIVE SYSTEM	OK
Drain transmission fluid	S.R.
Replace filter/gasket	S.R.
Check hoses and connections	S.R.
Replace transmission fluid	S.R.
Check for fluid leaks	S.R.
Remarks: None noted.	
LUBRICATION	OK
Drain crankcase oil	S.R.
Replace filters	S.R.
Replace crankcase oil	S.R.
Check for oil leaks	S.R.
Check oil level	S.R.
Lube all chassis grease fittings	S.R.
Lube universal joints	S.R.
Replace differential lube including axles	S.R.
Remarks: None noted.	

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 3 of 3

Bus Number: 1411	Date: 4-22-15
Personnel: T.S., S.R. & J.S.	
EXHAUST/EMISSION SYSTEM	OK
Check for exhaust leaks	S.R.
Remarks: None noted.	
ENGINE	OK
Replace air filter	S.R.
Inspect air compressor and air system	S.R.
Inspect vacuum system, if applicable	S.R.
Check and adjust all drive belts	S.R.
Check cold start assist, if applicable	S.R.
Remarks: None noted.	
STEERING SYSTEM	OK
Check power steering hoses and connectors	S.R.
Service fluid level	S.R.
Check power steering operation	S.R.
Replace transmission fluid	S.R.
Remarks: None noted.	
	OK
Ballast bus to seated load weight	S.R.
TEST DRIVE	OK
Check brake operation	S.R.
Check transmission operation	S.R.
Remarks: None noted.	

FUEL ECONOMY PRE-TEST INSPECTION FORM

Page 1 of 1

Bus Number: 1411	Date: 4-27-15
Personnel: T.S., S.R. & J.S.	
PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	J.S.
Cold tire pressure (psi): Front <u>120</u> Middle <u>110</u> Rear <u>120</u>	J.S.
Engine oil level	J.S.
Engine coolant level	J.S.
Interior and exterior lights on, evaporator fan on	J.S.
Fuel economy instrumentation installed and working properly.	S.R.
Fuel line -- no leaks or kinks	S.R.
Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TECH and Driver.	S.R.
Bus is loaded to SLW	S.R.
WARM-UP	If OK, Initial
Bus driven for at least one hour warm-up	S.R.
No extensive or black smoke from exhaust	S.R.
POST WARM-UP	If OK, Initial
Warm tire pressure (psi): Front <u>130</u> Middle <u>118</u> Rear <u>130</u>	T.S.
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	T.S.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 1 of 4

Bus Number: 1411		Manufacturer: Alexander Dennis		Date: 4-27-15			
Run Number: 1		Personnel: T.S., S.R. & J.S.					
Test Direction: <input checked="" type="checkbox"/> CW or <input type="checkbox"/> CCW		Temperature (°F): 50		Humidity (%): 53			
SLW (lbs.): 49,620		Wind Speed (mph) & Direction: 10 / NW		Barometric Pressure (in.Hg): 29.79			
Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish			Start	Finish	
CBD #1	0	9:08	9:08	25.5	0	.605	.605
ART #1	0	4:19	4:19	26.0	0	.544	.544
CBD #2	0	9:04	9:04	25.7	0	.604	.604
ART #2	0	4:25	4:25	26.7	0	.545	.545
CBD #3	0	9:07	9:07	26.3	0	.603	.603
COMMUTER	0	6:02	6:02	27.3	0	.588	.588
Total Fuel = 3.489 gals							
20 minute idle : Total Fuel Used = 0.216 gals							
Heating Value = 19,568 BTU/LB							
Comments: None noted.							

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 2 of 4

Bus Number: 1411		Manufacturer: Alexander Dennis		Date: 4-27-15			
Run Number: 2		Personnel: T.S., S.R. & J.S.					
Test Direction: <input type="checkbox"/> CW or <input checked="" type="checkbox"/> CCW		Temperature (°F): 51		Humidity (%): 49			
SLW (lbs.): 49,620		Wind Speed (mph) & Direction: 11 / NNW Barometric Pressure (in.Hg): 29.79					
Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish			Start	Finish	
CBD #1	0	9:10	9:10	25.8	0	.599	.599
ART #1	0	4:15	4:15	26.0	0	.554	.554
CBD #2	0	9:07	9:07	26.0	0	.609	.609
ART #2	0	4:15	4:15	27.5	0	.546	.546
CBD #3	0	9:05	9:05	27.2	0	.602	.602
COMPUTER	0	6:00	6:00	27.2	0	.598	.598
Total Fuel = 3.508 gals							
20 minute idle : Total Fuel Used = N/A gals							
Heating Value = 19,568 BTU/LB							
Comments: None noted.							

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 3 of 4

Bus Number: 1411		Manufacturer: Alexander Dennis		Date: 4-27-15			
Run Number: 3		Personnel: T.S., S.R. & J.S.					
Test Direction: <input checked="" type="checkbox"/> CW or <input type="checkbox"/> CCW		Temperature (°F): 52		Humidity (%): 49			
SLW (lbs.): 49,620		Wind Speed (mph) & Direction: 6 / NNW					
Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish			Start	Finish	
CBD #1	0	9:07	9:07	27.4	0	.602	.602
ART #1	0	4:18	4:18	27.6	0	.539	.539
CBD #2	0	9:05	9:05	27.1	0	.595	.595
ART #2	0	4:20	4:20	29.4	0	.538	.538
CBD #3	0	9:08	9:08	28.3	0	.589	.589
COMMUTER	0	6:02	6:02	27.7	0	.591	.591
Total Fuel = 3.454 gals							
20 minute idle : Total Fuel Used = N/A gals							
Heating Value = 19,568 BTU/LB							
Comments: None noted.							

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 4 of 4

Bus Number: 1411		Manufacturer: Alexander Dennis		Date: 4-28-15			
Run Number: 4		Personnel: T.S., S.R. & J.S.					
Test Direction: <input type="checkbox"/> CW or <input checked="" type="checkbox"/> CCW		Temperature (°F): 52		Humidity (%): 61			
SLW (lbs.): 49,620		Wind Speed (mph) & Direction: 9 / N		Barometric Pressure (in.Hg): 29.97			
Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish			Start	Finish	
CBD #1	0	9:03	9:03	27.7	0	.597	.597
ART #1	0	4:17	4:17	27.2	0	.552	.552
CBD #2	0	9:02	9:02	27.6	0	.615	.615
ART #2	0	4:20	4:20	28.7	0	.558	.558
CBD #3	0	9:06	9:06	26.9	0	.608	.608
COMMUTER	0	6:01	6:01	29.0	0	.609	.609
Total Fuel = 3.539 gals							
20 minute idle : Total Fuel Used = 0.227 gals							
Heating Value = 19,568 BTU/LB							
Comments: None noted.							

FUEL ECONOMY SUMMARY SHEET

BUS MANUFACTURER : **Alexander Dennis** BUS NUMBER: **1411**
 BUS MODEL : **E 500** TEST DATE : 04/28/15

FUEL TYPE : DIESEL
 SP. GRAVITY : .8505
 HEATING VALUE : 19568.00 BTU/Lb
 FUEL TEMPERATURE : 80.00 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)
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Run #: 1, CW				
CBD	1.812	5.73	3.162	2.86
ART	1.089	3.82	3.508	3.17
COM	.588	3.82	6.497	5.87
TOTAL	3.489	13.37	3.832	3.46

Run #: 2, CCW				
CBD	1.810	5.73	3.166	2.86
ART	1.100	3.82	3.473	3.14
COM	.598	3.82	6.388	5.77
TOTAL	3.508	13.37	3.811	3.45

Run #: 3, CW				
CBD	1.786	5.73	3.208	2.90
ART	1.077	3.82	3.547	3.21
COM	.591	3.82	6.464	5.84
TOTAL	3.454	13.37	3.871	3.50

Run #: 4, CCW				
CBD	1.820	5.73	3.148	2.85
ART	1.110	3.82	3.441	3.11
COM	.609	3.82	6.273	5.67
TOTAL	3.539	13.37	3.778	3.42

IDLE CONSUMPTION (MEASURED)

First 20 Minutes Data : .22GAL Last 20 Minutes Data: .23GAL
 Average Idle Consumption: .66GAL/Hr

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

Run 1: .2 Run 2: -.3 Run 3: 1.2 Run 4: -1.2

SUMMARY (CORRECTED VALUES)

Average Idle Consumption : .74 G/Hr
 Average CBD Phase Consumption : 2.87 MPG
 Average Arterial Phase Consumption: 3.16 MPG
 Average Commuter Phase Consumption: 5.79 MPG
 Overall Average Fuel Consumption : 3.46 MPG
 Overall Average Fuel Consumption : 24.91 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 42.1 dB(A); ranging from 37.6 dB(A) at the rear passenger seats to 44.5 dB(A) in line with the middle speaker. The interior ambient noise level for this test was < 30.0 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 driver's seat to 76.4 dB(A) at the rear passenger seats. The overall average was 73.3 dB(A). The interior ambient noise level for this test was < 34.0 dB(A).

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

INTERIOR NOISE TEST DATA FORM

Test Condition 1: 80 dB(A) Stationary White Noise

Page 1 of 3

Bus Number: 1411	Date: 01/23/15
Personnel: T.S. & E.D.	
Temperature (°F): 39	Humidity (%): 72
Wind Speed (mph): 2	Wind Direction: SSW
Barometric Pressure (in.Hg): 30.19	
Initial Sound Level Meter Calibration: 93.7 dB(A)	
Interior Ambient Noise Level dB(A): < 30.0	Exterior Ambient Noise Level dB(A): 47.3
Microphone Height During Testing (in): 48	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	42.5
Front Passenger Seats	42.8
In Line with Front Speaker	43.9
In Line with Middle Speaker	44.5
In Line with Rear Speaker	41.1
Rear Passenger Seats	37.6

Final Sound Level Meter Calibration: 93.7 dB(A)

Comments: None noted.

INTERIOR NOISE TEST DATA FORM
Test Condition 2: 0 to 35 mph Acceleration Test
Page 2 of 3

Bus Number: 1411	Date: 4-16-15
Personnel: S.R., E.D. & M.H.	
Temperature (°F): 59	Humidity (%): 26
Wind Speed (mph): 6	Wind Direction: S
Barometric Pressure (in.Hg): 30.39	
Initial Sound Level Meter Calibration: 93.8 dB(A)	
Interior Ambient Noise Level dB(A): < 34.0	Exterior Ambient Noise Level dB(A): 44.2
Microphone Height During Testing (in): 29.0 above seat cushion.	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	70.3
Front Passenger Seats	73.2
Middle Passenger Seats	73.4
Rear Passenger Seats	76.4

Final Sound Level Meter Calibration: 93.8 dB(A)

Comments: None noted.

INTERIOR NOISE TEST DATA FORM

Test Condition 3: Audible Vibration Test

Page 3 of 3

Bus Number: 1411	Date: 4-16-15
Personnel: S.R., E.D. & M.H.	
Temperature (°F): 63	

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

Source of Noise	Location	Description of Noise
Engine and Accessories	None noted.	N/A
Windows and Doors	None noted.	N/A
Seats and Wheel Chair lifts	None noted.	N/A
Other	None noted.	N/A

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

7.1 INTERIOR NOISE TEST



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

7.2 EXTERIOR NOISE TESTS

7.2-I. TEST OBJECTIVE

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

7.2-II. TEST DESCRIPTION

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

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

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

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

During the test, special attention should be paid to:

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

7.2-III. DISCUSSION

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

With an exterior ambient noise level of 46.3 dB(A), the average test result obtained while accelerating from a constant speed was 80.9 dB(A) on the right side and 80.1 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 45.7 dB(A), the average of the results obtained were 82.3 dB(A) on the right side and 82.5 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 62.6 dB(A) at low idle, 68.1 dB(A) at high idle, and 75.2 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 1.4 dB(A) higher at low idle, 0.6 dB(A) lower at high idle, and 0.3 dB(A) lower at wide open throttle. The exterior ambient noise level measured during this test was 41.0 dB(A).

EXTERIOR NOISE TEST DATA FORM

Accelerating from Constant Speed

Page 1 of 3

Bus Number: 1411		Date: 4-16-15	
Personnel: S.R., E.D. & M.H.			
Temperature (°F): 50		Humidity (%): 28	
Wind Speed (mph): 9		Wind Direction: ESE	
Barometric Pressure (in.Hg): 30.40			
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ S.R.			
Initial Sound Level Meter Calibration: 93.8 dB(A)			
Exterior Ambient Noise Level: 46.3 dB(A)			
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	81.3	1	79.3
2	80.0	2	79.0
3	80.4	3	80.2
4	80.0	4	79.9
5	80.1	5	80.0
6		6	
7		7	
8		8	
9		9	
10		10	
Average of two highest actual noise levels = 80.9 dB(A)		Average of two highest actual noise levels = 80.1 dB(A)	
Final Sound Level Meter Calibration Check: 93.8 dB(A)			
Comments: None noted.			

EXTERIOR NOISE TEST DATA FORM

Accelerating from Standstill

Page 2 of 3

Bus Number: 1411		Date: 4-16-15	
Personnel: S.R., E.D. & M.H.			
Temperature (°F): 55		Humidity (%): 28	
Wind Speed (mph): 9		Wind Direction: ESE	
Barometric Pressure (in.Hg): 30.40			
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ S.R.			
Initial Sound Level Meter Calibration: 93.8 d(B)A			
Exterior Ambient Noise Level: 45.7 dB(A)			
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	82.5	1	81.5
2	81.4	2	82.3
3	81.5	3	82.7
4	81.9	4	81.0
5	82.1	5	82.1
6		6	
7		7	
8		8	
9		9	
10		10	
Average of two highest actual noise levels = 82.3 dB(A)		Average of two highest actual noise levels = 82.5 dB(A)	
Final Sound Level Meter Calibration Check: 93.7 dB(A)			
Comments: None noted.			

EXTERIOR NOISE TEST DATA FORM

Stationary

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Bus Number: 1411		Date: 4-16-15	
Personnel: S.R., E.D. & M.H.			
Temperature (°F): 57		Humidity (%): 40	
Wind Speed (mph): 6		Wind Direction: NNE	
Barometric Pressure (in.Hg): 30.42			
Initial Sound Level Meter Calibration: 93.8 dB(A)			
Exterior Ambient Noise Level: 41.0 dB(A)			
Accessories and Air Conditioning ON			
Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	700	62.8	62.3
High Idle	1,200	67.6	68.6
Wide Open Throttle	2,100	74.6	75.8
Accessories and Air Conditioning OFF			
Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	700	62.0	66.0
High Idle	1,200	66.6	68.3
Wide Open Throttle	2,100	74.2	75.5
Final Sound Level Meter Calibration Check: 93.8 dB(A)			
Comments: None noted.			

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, NO_x, 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). 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.

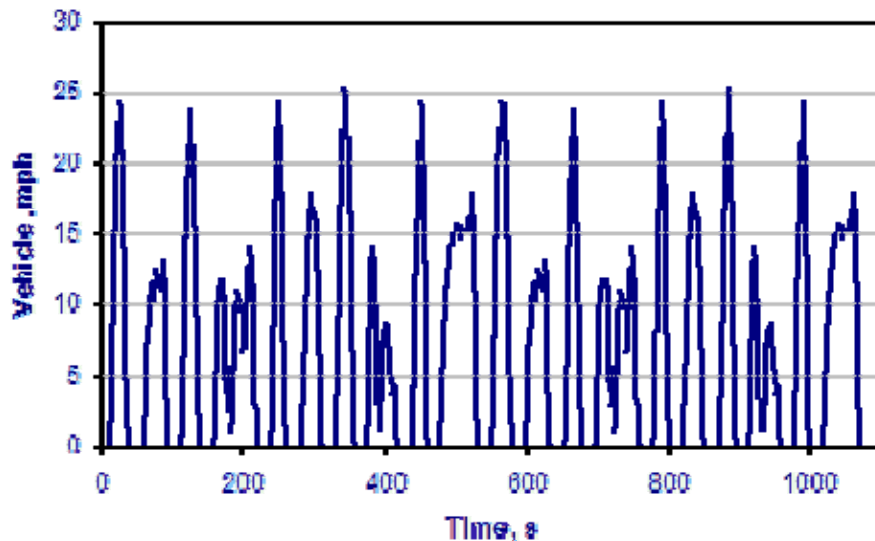


Figure 1. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4mph, average speed 6.8mph)

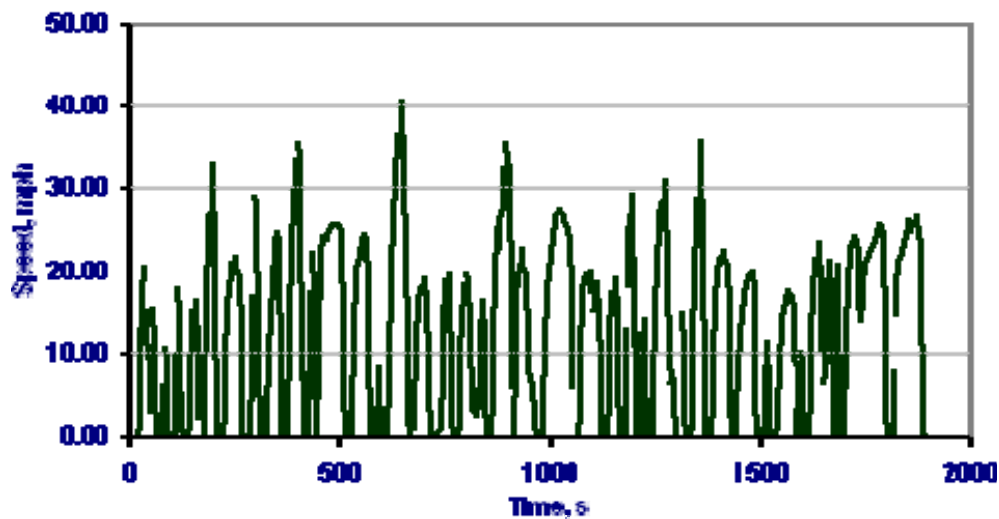


Figure 2. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41mph, Average Speed 12mph)

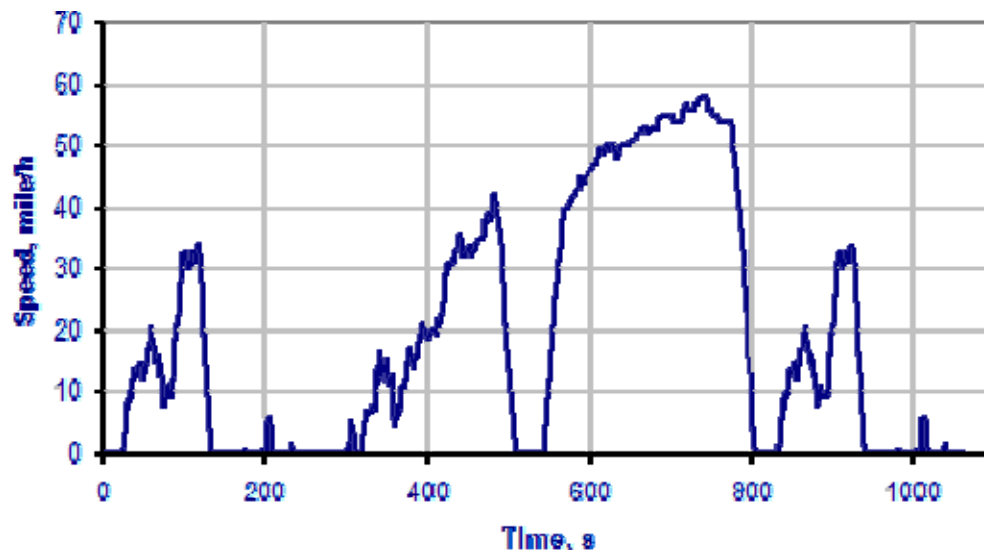


Figure 3. HD-UDDS Cycle (duration 1060seconds, Maximum Speed 58mph, Average Speed 18.86mph)

8-III. TEST ARTICLE

The test article is an Alexander Dennis Inc., model E500 transit bus equipped with diesel fueled Cummins ISL 9 engine. The bus was tested on April 30, 2015.

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

Test Completed at Half SLW: <u>43,050 lbs.</u>			
Driving Cycle	Manhattan	Orange County Bus	UDDS
CO₂, gm/mi	3,401	2,528	2,137
CO, gm/mi	0.24	0.04	0.01
THC, gm/mi	0.30	0.11	0.08
NMHC, gm/mi	0.26	0.09	0.06
NO_x, gm/mi	13.7	5.6	4.0
Particulates. gm/mi	0.009	0.009	0.003
Fuel consumption mpg	2.75	4.03	4.76