

FEDERAL TRANSIT BUS TEST

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

Altoona Bus Testing and Research Center Test Bus Procedure

7.1 INTERIOR NOISE TESTS

Pass/Fail
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**LTI BUS RESEARCH
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ABBREVIATIONS

ABTC	Altoona Bus Test Center
A/C	Air Conditioner
ADB	Advance design bus
CBD	Central business district
CI	Compression ignition
CNG	Compressed natural gas
CW	Curb weight (bus weight including maximum fuel, oil, and coolant; but without passengers or driver)
dB(A)	Decibels with reference to 0.0002 microbar as measured on the “A” scale
DIR	Test director
DR	Bus driver
EPA	Environmental Protection Agency
FFS	Free floor space (floor area available to standees, excluding ingress/egress areas, area under seats, area occupied by feet of seated passengers, and the vestibule area)
FTA	Federal Transit Administration
GAWR	Gross axle weight rating
GL	Gross load (150 lb. for every designed passenger seating position, for the driver, and for each 1.5 sq. ft. of free floor space)
GVW	Gross vehicle weight (curb weight plus gross vehicle load)
GVWR	Gross vehicle weight rating
hr.	Hour
LNG	Liquefied natural gas
LTI	Larson Transportation Institute
mpg	Miles per gallon
mph	Miles per hour
NBM	New bus models
PSTT	Penn State Test Track
rpm	Revolutions per minute
SAE	Society of Automotive Engineers
SCF	Standard cubic feet
SCFM	Standard cubic feet per minute
SCH	Test scheduler
SA	Staff Assistant
SI	Spark ignition
SLW	Seated load weight (curb weight plus 150 lb. for every designated passenger seating position and for the driver)
TD	Test driver
TM	Track manager
TP	Test personnel

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 PSTT.
2. The bus will accelerate at full throttle from a stationary position to 35 mph on a level pavement at the PSTT. All openings will be closed and all accessories will be operating during the test.
3. The bus will be operated at various speeds up to 55 mph with and without the air conditioning and accessories on. Any audible vibrations or rattles will be noted. This test will be performed on the test segment between the PSTT and the ABTC.

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. TEST ARTICLE

The test article is a transit bus with a minimum service life of 4, 5, 7, 10 or 12 years.

7.1-IV. TEST EQUIPMENT/FACILITIES/PERSONNEL

Test equipment

1. Tape measure (50 ft.) or a wheeled distance meter
2. Calibrated sound level meter with microphone and windscreen
3. Calibrated weather equipment

NOTE: The sound level meter must meet or exceed Type 1 or S1A requirements of American National Standard Specification for sound level meters. The windscreen shall not affect the microphone response more than +1 dB (A) for frequencies of 20 to 4000 Hz or +1 ½ dB(A) for frequencies of 4000 to 10,000 Hz.

4. Calibrated sound level calibrator
5. White noise generating system
6. Speaker stands
7. Non-calibrated anemometer pen (for reference only).
8. Camera

Test Facilities

1. Test condition 1 and Test condition 2 will be performed on the test track at the PSTT. Test condition 3 will be performed on the test segment between the ABTC and the PSTT.
2. For test condition #1 and #2, the test areas shall be free of reflecting surfaces, such as parked vehicles, trees or buildings, within 100 ft. of the measurement area. The area shall also be free of snow or other sound absorbing material.
3. The ambient sound level (including wind effects) at the test site shall be at least 10 dB(A) below the sound level of the test vehicle operated in accordance with the test procedures.
4. The wind speed in the measurement area shall not have gusts greater than 12 mph.

Test Personnel – The test personnel consist of the following:

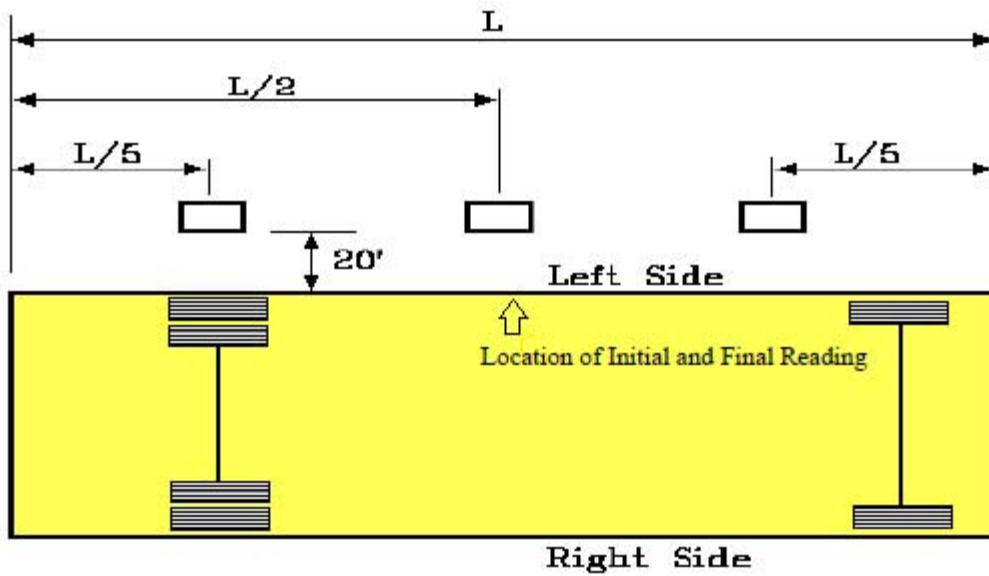
1. Test Driver (TD)
2. Test Personnel (TP)

7.1-V. TEST DATA

The test data consists of the Interior Noise Test Data Form. All forms must be completed using pen. Upon completion of the test, the test data will be forwarded to the ABTC manager.

7.1-VI. TEST PREPARATION AND PROCEDURES

The detailed test preparation and procedures are listed in Procedures 7.1-1, 7.1-2 and 7.1-3. This section also includes Interior Noise Test Data Forms – 7.1-1, 7.1-2 and 7.1-3



Length = Length of bus

Speakers 1, 2 and 3 are supported such that their centers are approximately 5 ft. above paved ground level and level to the ground.

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-1	NOMENCLATURE: 7.1 Interior Noise Condition 1: Stationary	
OPER STEP	ACTION BY	TEST PREPARATION AND PROCEDURE
1	TP	Record the bus number, manufacturer and date on the Interior Noise Test Data Form 7.1-1.
2	TD	Position the test bus in the center of the test area
3	TP	Record the temperature, relative humidity, wind speed, wind direction and barometric pressure, and ambient sound level on the Interior Noise Data Form. NOTE: Confirm using a calibrated anemometer pen that the wind speed/gusts are approximately less than 12 mph. Using the calibrated weather instrument, verify the ambient temperature is between 30° F and 90° F.
4	TP	Verify operation of the sound level meter using the sound level calibrator as per the meter's instruction manual. Record value on test data form. Set the meter for the "A-weighting" network and the "fast response" position. Switch the sound level meter to the "auto" position. Measure and record the ambient sound level at the exterior and interior of the bus. NOTE: When taking sound level measurements, position the sound level meter at least arm's length away from the body.
5	TP	Position the white noise generating system on the left side of the bus as indicated by Figure 7.1. The speaker stands shall position the center of each speaker at approximately 5 ft. above paved ground level and level to the ground.
6	TP	Photograph the test area and setup. NOTE: The sound system, as positioned in Figure 7.1, must be capable of generating a uniform white noise level of 80 db(A) +2 dB(A) at the left exterior surface of the bus.
7	TP	Switch on the noise generating system and set the output to some intermediate level. NOTE: The sound level meter should be positioned within approximately 12 inches from the surface of the test bus with the microphone pointing away from and perpendicular to the surface of the bus.

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-1	NOMENCLATURE: 7.1 Interior Noise Condition 1: Stationary (continued)	
OPER STEP	ACTION BY	TEST PREPARATION AND PROCEDURE
8	TP	Using the sound level meter, check the noise level at the surface of the bus.
9	TP	Adjust the output of the white noise generating system to produce a uniform noise level equal to 80 dB(A) +2 dB(A) on the exterior surface of the bus. See diagram for initial and final reading locations on data sheet.
10	TP	Sweep the entire left exterior surface of the bus with the sound meter and adjust the output of the noise generating system until the required level has been achieved. NOTE: The speakers should not be moved away or toward the bus to obtain the 80dB (a) noise level. The test personnel should not interfere with the sound field when trying to obtain the 80dB(A) noise level.
11	TP	Once 80 dB(A) +2 dB(A) has been established, move the meter inside the test bus. NOTE: All windows, hatches, doors and vents shall be in the fully closed position. All accessories and the engine shall be "off."
12	TP	Establish a reference point that approximates the ear-level position of a seated passenger by measuring a distance of approximately 29 inches vertically upward from the predominant surface of the undeflected seat cushion. Using this reference point, position the microphone at the predetermined height by connecting the noise level meter to the tri-pod/mono-pod and adjusting the height of the tri-pod. Use caution to not block the sound field when reading the measurement. Record the microphone height (distance from the floor of the bus in front of seat to the microphone) on the Interior Noise Test Data Form page 1.

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-1	NOMENCLATURE: 7.1 Interior Noise Condition 1: Stationary (continued)	
OPER STEP	ACTION BY	TEST PREPARATION AND PROCEDURE
13	TP	<p>Position the microphone at the height, measured in step 12, pointing vertically upward at an angle of approximately 70 degrees and perpendicular to the left side of the bus. With the microphone in the prescribed position, take noise level readings at the following six locations:</p> <ol style="list-style-type: none"> 1. Driver's seat 2. Center aisle, between front passenger seats 3. Center aisle, in line with front speaker 4. Center aisle, in line with center speaker 5. Center aisle, in line with rear speaker 6. Center aisle, between rear passenger seats <p>Record the highest noise level reading at each location on the Interior Noise Test Data Form 7.1-1.</p> <p>NOTE: Unrelated peak readings due to extraneous noises (talking, etc.) should be ignored and omitted from the test data.</p>
14	TP	<p>Using the sound level calibrator, recheck the calibration of the sound level meter. If the value has changed by more than 0.5 dB(A), recalibrate the meter and repeat all tests since the last calibration. Record value on test data form.</p>

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-2	NOMENCLATURE: 7.1 Interior Noise Condition 2: 0 to 35 mph Acceleration Test	
OPER STEP	ACTION BY	TEST PREPARATION
1	TP	Record the bus number, manufacturer and date on the Interior Noise Test Data Form 7.1-2.
2	TP	Record the temperature, relative humidity, wind speed, barometric pressure and wind direction on the test data form. NOTE: Confirm approximately using a non-calibrated anemometer pen that the wind speed/gusts are less than 12 mph. Using the calibrated weather instrument, verify the ambient temperature is between 30° F and 90° F.
3	TP	Calibrate the sound level meter using the sound level calibrator, as per the meter's instruction manual. Record reading on test data form.
4	TP	Measure the ambient sound level at the exterior and interior of the test vehicle and record the values on the Interior Noise Test Data Form. If the sound level cannot be recorded due to the scale on the sound level meter, then record the lowest reading that is obtainable [34 dB(A)].
5	TP	Establish a reference point that approximates the ear-level position of a seated passenger by measuring a distance of approximately 29 inches vertically upward from the predominant surface of the undeflected seat cushion. Using this reference point, connect the tripod to the sound level meter and position the tripod to the predetermined height. Record the microphone height (distance between the microphone and the floor of the bus in front of the seat) on the Interior Noise Test Data Form page 2.
6	TD	Drive the bus, loaded to SLW, on the test track until it has reached normal operating temperature.
7	TD	Close all windows, doors and other openings.

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-2	NOMENCLATURE: 7.1 Interior Noise Condition 2: 0 to 35 mph Acceleration Test (continued)	
OPER STEP	ACTION BY	TEST PREPARATION
8	TD	Start the engine and place the transmission in "Drive." Do not move the vehicle. Switch all accessories on, except air conditioning.
9	TP	Position the microphone at the predetermined height, pointing vertically upward at approximately 70 degrees, in the rear most passenger seating position.
10	TD	Accelerate the bus at full throttle from a stationary position to a speed of 35 mph. Visually notify the test personnel when a speed of 35 mph has been reached. Proceed around the test track to the starting position and stop the bus.
11	TP	Observe the sound level while the bus is accelerating to 35 mph. Record the highest measured level, while the bus is accelerating from 0 to 35 mph, on the Interior Noise Test Data Form.
12	TP	Position the microphone at the predetermined height pointing vertically upward at approximately 70 degrees, in the middle of the passenger compartment.
13	TD	Repeat step 10.
14	TP	Repeat step 11.
15	TP	Position the microphone at the predetermined height, pointing vertically upward at approximately 70 degrees, in between the front most passenger seats.
16	TD	Repeat step 10.
17	TP	Repeat step 11.
18	TP	Position the microphone at the predetermined height, pointing vertically upward at approximately 70 degrees, at the driver's position.

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-2	NOMENCLATURE: 7.1 Interior Noise Condition 2: 0 to 35 mph Acceleration Test (continued)	
OPER STEP	ACTION BY	TEST PREPARATION
19	TD	Repeat Step 10.
20	TP	Repeat Step 11.
21	TP	Using the sound level calibrator, recheck the calibration value of the sound level meter. If the value has changed by more than +0.5 dB(A), recalibrate the meter and repeat all tests since the last calibration. Record reading on the Interior Noise Test Data Form.
22	TP	Verify that all test requirements have been completed.

DETAILED TEST PROCEDURES		TITLE: 7. Noise
Procedure 7.1-3	NOMENCLATURE: 7.1 Interior Noise Condition 3: Audible Vibration Test	
OPER STEP	ACTION BY	TEST PREPARATION
1	TP	Record the bus number, date, and temperature on the Interior Noise Test Data Form 7.1-3. NOTE: This test is an “over the road” test. The test segment consists of the sections of roadway between the ABTC and the PSTT.
2	TD	Cycle the air conditioning, and all accessories on and off every 15 minutes during the course of travel.
3	TD	While the bus is operating over the test course, observe the relative magnitude of any resonant vibrations or rattles, giving a description of the location and the conditions under which the event(s) occurred. Record all observations and comments on the Interior Noise Test Data Form 7.1-3.