NHTSA
Quiet Vehicle Compliance Tool
User Guide

Version 2.0.2.0

Table of Contents

1 Release Notes and Known Issues

A list of changes from the Compliance Tool version Beta 1 is included below.

- Added second trigger at line A-A' to tell the compliance tool where the start of the measurement is rather than expecting the measurement to begin at the beginning of the .wav file.
- Updated logs to include the front samples.
- Fixed a bug where the stationary and directivity results were the same in the logs. This was a bug in writing to the log, not in the calculations.
- Assigned a value of -9999 to bands that are invalid (the difference between the 1/3 octave band sound pressure and ambient noise level is less than or equal to 3 dB).
- Fixed a bug to use the input trigger value not the default value.
- Updated the default trigger value from 50% to 20%.
- Updated tool spreadsheet output format.
- Added detail to the documentation on the following topics:
    - Added this section on release notes
    - System Requirements and Installation Instructions
        - Updated operating system requirement from Windows 7 to Windows 10
        - Updated hard drive space from 900 KB to 16 MB
        - Updated the required Matlab Runtime Library Version from 12a to the 64-bit 2019b
        - Added information on .wav file scaling
    - Added a section on Data Requirements.
        - Added information on expected trigger locations.

Known issues in version 2.0.2.0

Known issues include unexpected software behaviors that have not been prioritized for fixing in this software version and do not impact critical software functionality. Known issues for 2.0.2.0 are:

- Waveform review:
  The GUI may not display the expected waveform if waveforms are reviewed out of order or if a review button such as [Review Next] is selected before all waveforms from a sample set have been displayed. *Workaround*: Review the waveforms in a separate program (e.g. the program used to collect data) or wait for the waveforms to cycle prior to selecting another GUI control item.
- Trigger setting:
  In some cases, the trigger threshold value may not be recognized in the software if it is not entered immediately before selecting [Compute Analysis]. *Workaround*: Type the desired trigger threshold value into the GUI entry box, and then use the [Enter] keyboard button to save the value. Do not select any other options on the GUI prior to selecting [Compute Analysis].

2 Introduction

The National Highway Traffic Safety Administration (NHTSA), Office of Vehicle Safety Compliance (OVSC) has developed the Quiet Vehicle Compliance Tool to determine if pedestrian alert sounds for motor vehicles meet the standard established in Federal Motor Vehicle Safety Standard(s) (FMVSS) 141 Regulation.

This tool was developed to be used by the test technician after execution of all test series (i.e., stationary, reverse, and pass-by tests) have been completed and four valid test runs have been collected. It is the responsibility of the test technician to eliminate tests that are invalid due to audio contamination (e.g. birds chirping), while this tool will determine if a sequence of tests meet the requirements. The analysis conducted in this tool is described further in Section 2.3.

The U.S. Department of Transportation (US DOT), National Highway Traffic Safety Administration (NHTSA) laboratory test procedure (TP-141) for FMVSS 141 Minimum Sound Requirements for Hybrid and Electric Vehicles document describes the test procedure in detail.

NOTE: Like the OVSC Laboratory Test Procedures, the Quiet Vehicle Compliance Tool software and its documentation are prepared for the limited purpose of use by independent laboratories under contract to conduct compliance tests for the OVSC. They are not rules, regulations or NHTSA interpretations regarding the meaning of a FMVSS. The laboratory test procedures and associated software/documentation are not intended to limit the requirements of applicable FMVSSs. They may not include all of the various FMVSS minimum performance requirements. Recognizing applicable test tolerances, the software/documentation may specify test conditions that are less severe than the minimum requirements of the standard. In addition, the software/documentation may be modified by the OVSC at any time without notice, and the COR may direct or authorize contractors to deviate from these procedures, as long as the tests are performed in a manner consistent with the standard itself and within the scope of the contract.

NHTSA is providing the software herein for informational purposes for the public to understand how compliance tests will be conducted. NHTSA provides the software as-is and provides no other warranties, express or implied. A passing result from the software does not guarantee compliance with FMVSS 141.

2.1 About this User Guide

This User Guide provides instructions on how to interact with the Quiet Vehicle Compliance Tool. It is organized according to the suggested workflow.

Note that the images in this user guide are not intended to represent a real analysis. Example data has been used to demonstrate the functionality of the tool, not to represent real measurement data.

2.2 Terminology

dB	Decibel. Used when no standard weighting affects the value, e.g. when differences between one-third octave band levels are reported.
dBA	Used to refer to A-weighted sound pressure level (SPL) in decibels for overall, one-third octave, and band sum levels.
Operating Condition	State of vehicle during measurement. Each of the following can be analyzed using this tool: Stationary, Reverse, 10 km/h Pass-by, 20 km/h Pass-by, and 30 km/h Pass-by
Operation	The movement of the vehicle for a single measurement.
Signal	A series of data sampled uniformly in time
Sample	A combination of driver side, passenger side, front (for stationary operations), trigger (for pass-by operations), and pre- and post-ambient measurement data for a single operation.
Sound	Signal that consists of data from one of three possible microphone channels (Driver, Passenger, Front)
Sound Channel	Channel in the .wav file that contains a sound
SPL	Sound Pressure Level
Test	The measurement of a period of time that contains a single stationary, reverse or pass-by operating condition
Test Series	A sequence of tests for the same operating condition
Trigger	Signal that consists of data that indicate by an increase in level that a vehicle has passed by a sensor
Trigger Channel	Channel in the .wav file that contains a trigger

2.3 Analysis Computations

Figure 1 describes the analysis that is completed within the Quiet Vehicle Compliance Tool with references to the relevant sections in the final rule. Additional information on data processing is included in Appendix III.

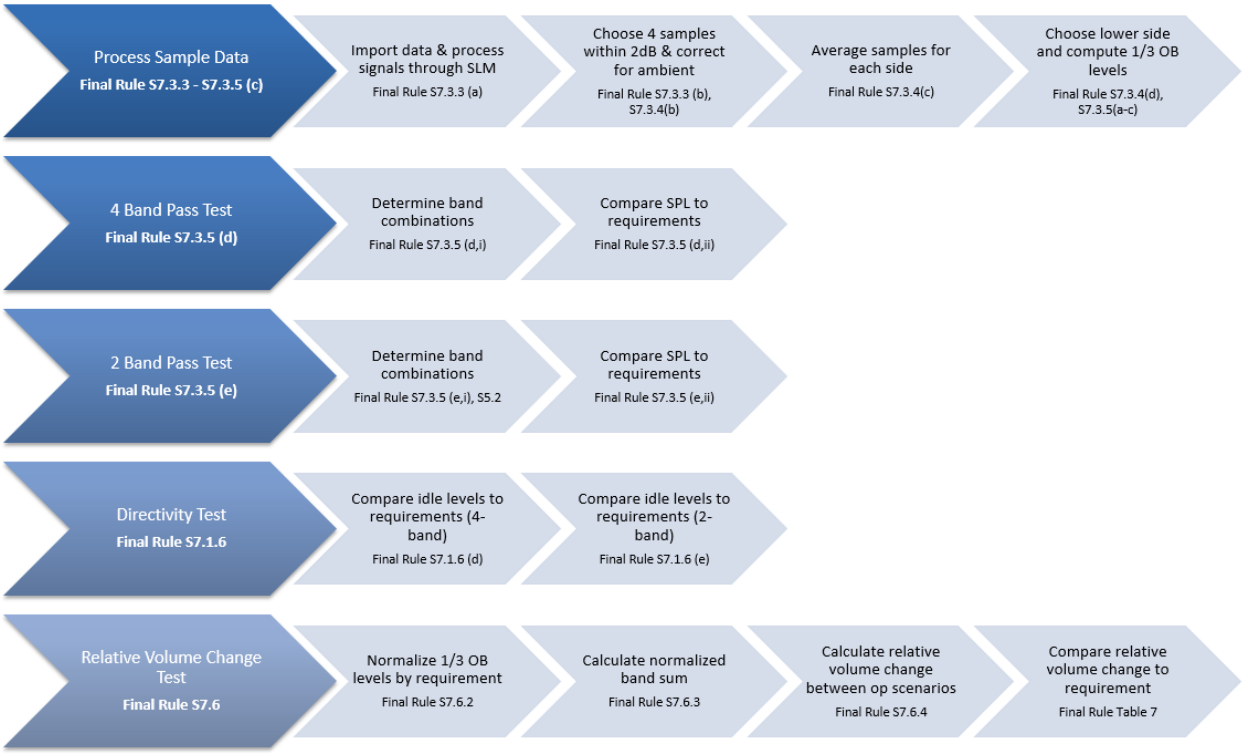

Figure 1: Analysis Workflow in the Quiet Vehicle Compliance Tool

3 System Requirements and Installation Instructions

The Quiet Vehicle Compliance Tool will run on a 64-bit Windows 10 (or later) PC with at least 16 GB of RAM. The tool requires approximately 16 MB of Hard Drive Space, plus the space required for the MATLAB Runtime Library[1], Version 2019b. A minimum screen resolution of 1024 x 768 (XGA) is recommended.

To install the tool, extract the files (NHTSA_QVCT.exe and the BaseData.bin file are the critical files) to a folder that you have permission to run executables from. Note that the BaseData.bin file and the NHTSA_QVCT.exe must be in the same folder. For convenience, users may want to pin the application to the Start Menu or Toolbar.

Critical file hashes (SHA256):
To permit users to validate the integrity of downloaded software from the NHTSA website, file hashes have been generated for the files critical to software operation using the SHA256 algorithm for comparison. Users may generate file hashes for these downloads in Microsoft Powershell using the *Get-FileHash* command[2] or another suitable utility for generating SHA256 file hashes.

Table 1: Critical File Hashes (SHA256)

Hash	Filename
22D8E74EEEEEC1FA2D6BA0EAC221074594E4017A54464105D48675A49BBA4944	BaseData.bin
8673E4E411DC288EBDEF9E789F1E14A33659F0B7A8FDA7BF1AF7C856CFE3D16B	NHTSA_QVCT.exe

Supplemental Tool Requirements

- MATLAB Runtime Library Version 2019b
  To install the MATLAB Runtime, download the 64-bit installer from the following link on the Mathworks website, https://www.mathworks.com/products/compiler/matlab-runtime.html. Then follow the instructions found at this link. Note, you must install Version 2019b in order to run the Quiet Vehicle Compliance Tool.

- Microsoft Excel
  The Quiet Vehicle Compliance Tool writes log files to excel spreadsheets.

[1] Machine with lower capabilities may work, but have not been tested.
[2] For additional information on *Get-FileHash* see https://docs.microsoft.com/en-us/powershell/module/microsoft.powershell.utility/get-filehash

4 Data Requirements

Data are expected to be imported into the tool in the .wav format with a sampling frequency of 44,100 Hz. If the sampling frequency of the measured data is not 44,100 Hz it should be resampled before using in this tool. If the data are not resampled prior to running the analysis, they will be resampled to 44,100 Hz during computations and the computation time will increase.

The compliance tool is expecting the data in the .wav file to be uncompressed, 16 or 32-bit floats with full scale of +/- 1 Pascal.

For pass-by tests, the compliance tool expects triggers from sensors at line A-A' and P-P'. For more information on triggers, see Appendix II.

5 Workflow

It is recommended to use the Quiet Vehicle Compliance Tool in the following order:

1. Start the Quiet Vehicle Compliance Tool (Section 6)
2. Import data individually or multiple files at a time (Section 7)
3. Record vehicle information and user comments (Section 8)
4. Review the data and discard any contaminated samples (Section 9)
5. Compute results (Section 10)
6. Review output (Section 11)

6 Starting the Quiet Vehicle Compliance Tool

Navigate to the folder where the executable is installed. Double-click on the NHTSA_QVCT.exe file to open the Quiet Vehicle Compliance Tool. Note that it may several minutes for the tool to load.

When the Quiet Vehicle Compliance Tool first starts, it should look like Figure 2. The Quiet Vehicle Compliance Tool consists of five main areas (Figure 3). Area (A) allows for the user to select and import data files. Area (B) is where information related to the test vehicle is recorded. Area (C) is where the user can enter any comments relevant to the analysis. Area (D) provides methods to evaluate the data quality and allows for discarding of contaminated data. Area (E) handles the tasks related to the processing of the data and provides a summary of results upon completion of the analysis.

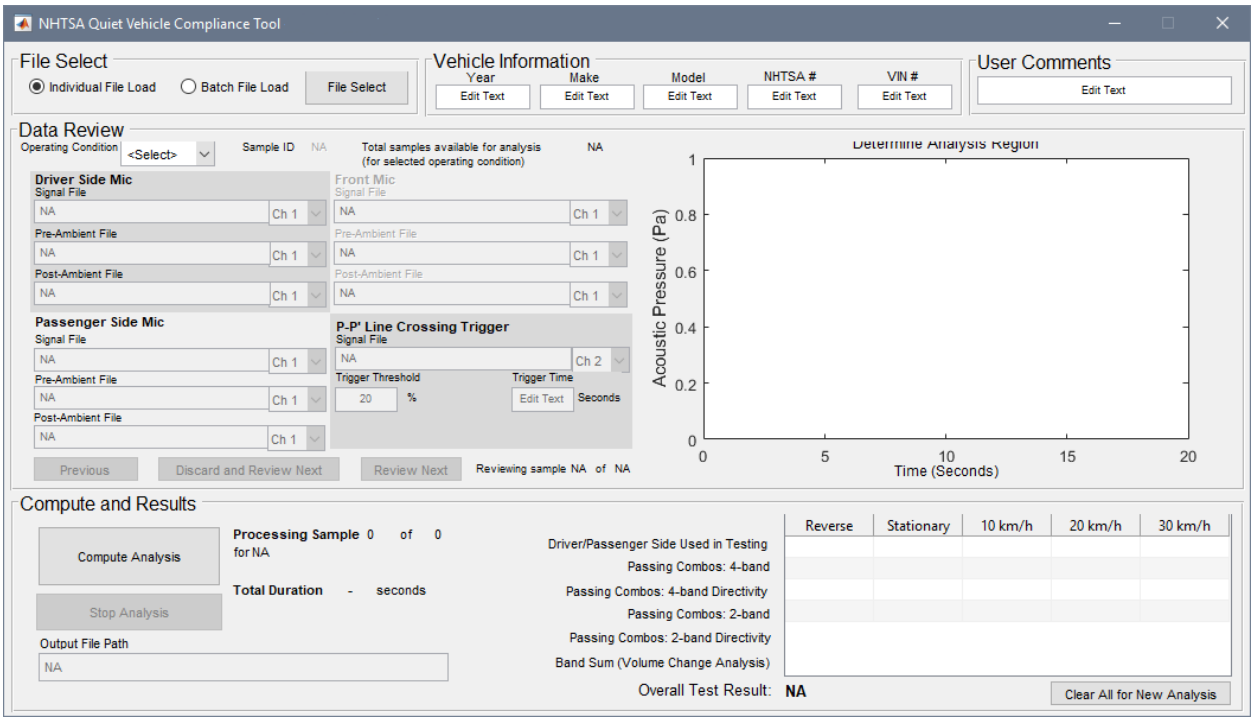

Figure 2: Quiet Vehicle Compliance Tool at Launch

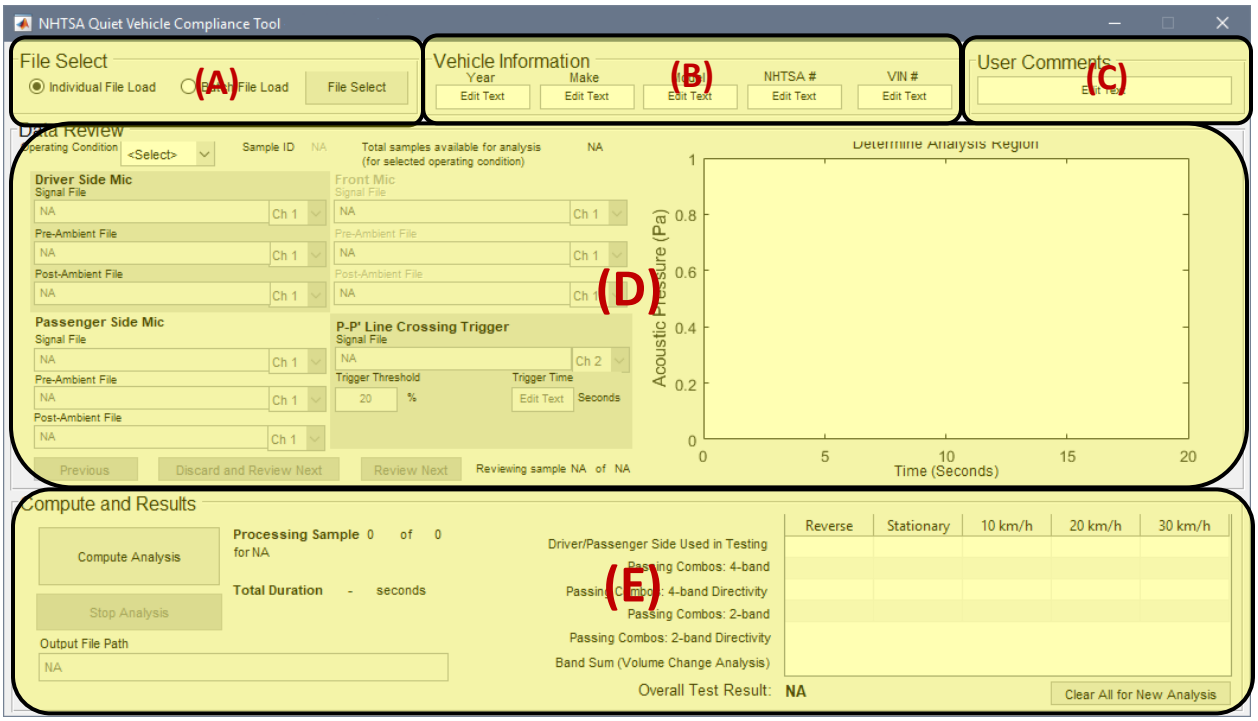

Figure 3: Areas of the Quiet Vehicle Compliance Tool

7 Importing Data

Data are loaded into the tool in Area (A), see Figure 3. The data required for running the compliance analysis in this tool includes at least four samples of each operating condition (pass-by, stationary, or reverse) in .wav format with a sampling frequency of 44,100 Hz.[3] Note that once data has been imported into this tool, the data can be reviewed in the main window and corrupted samples can be discarded (Section 9). At least four samples must be present after reviewing the data in order to proceed with the analysis.

These samples should include the following data by operation type. Files can be imported into the Quiet Vehicle Compliance Tool individually (Section 7.1) or in a batch (Section 7.2)

- Pass-bys (10 km/h, 20 km/h, 30 km/h):
    - Driver signal
    - Driver pre-ambient
    - Driver post-ambient
    - Passenger signal
    - Passenger pre-ambient
    - Passenger post-ambient
    - Trigger signal
- Stationary:
    - Driver signal
    - Driver pre-ambient
    - Driver post-ambient
    - Passenger signal
    - Passenger pre-ambient
    - Passenger post-ambient
    - Front signal
    - Front pre-ambient
    - Front post-ambient
- Reverse:
    - Driver signal
    - Driver pre-ambient
    - Driver post-ambient
    - Passenger signal
    - Passenger pre-ambient
    - Passenger post-ambient

7.1 Individual File Load

Importing files individually allows for the user to select all components of a sample individually. First, all the files associated with one sample are selected and imported into the queue for data submittal. Once

[3] If the sampling frequency of the measured data is not 44,100 Hz it should be resampled before using in this tool. If the data are not resampled prior to running the analysis, they will be resampled to 44,100 Hz during computations and the computation time will increase.

at least 4 samples for each operating condition have been imported, the user can submit the data and return to the main window for further analysis.

To import the files individually:

1. Within the Quiet Vehicle Compliance Tool's main window, **File Select** section, select the **Individual File Load** radio button and click **File Select** (Figure 4) to open the **File Load** window (Figure 5).

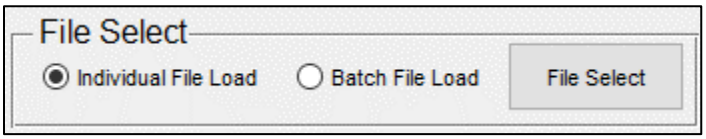

Figure 4: File Select – Individual File Load

2. In the **User Input** section, select or enter the following for the sample:
    a. **Operating Condition**: Select the type of operation from the drop-down menu. The available options include **Stationary**, **10km/h**, **20 km/h**, **30km/h**, and **Reverse**.
    b. **Sample ID**: Enter a user-defined numeric identifier if desired. If an identifier is not entered, the tool will assign an ID of 1 if there is no other data. If data exists, the highest ID will be incremented by 1.
    c. Driver Side Mic:
        i. Click **Select File** and navigate to the .wav file containing the driver signal data and click **Open**.
        ii. Use the drop-down menu to select the channel of the .wav file where the driver signal data are stored.
        iii. Repeat steps i and ii for the driver side pre and post ambient .wav files.
    d. Passenger Side Mic:
        i. Click **Select File** and navigate to the .wav file containing the passenger signal data and click **Open**.
        ii. Use the drop-down menu to select the channel of the .wav file where the passenger signal data are stored.
        iii. Repeat steps i and ii for the passenger side pre and post ambient .wav files.
    e. Front Mic: These fields are only enabled for the Stationary operating condition.
        i. Click **Select File** and navigate to the .wav file containing the front signal data and click **Open**.
        ii. Use the drop-down menu to select the channel of the .wav file where the front signal data are stored.
        iii. Repeat steps i and ii for the front pre and post ambient .wav files.
    f. Cross P-P' Line Trigger: This field is only enabled for the pass-by operating conditions.
        i. Click **Select File** and navigate to the .wav file containing the trigger signal data and click **Open**.
        ii. Use the drop-down menu to select the channel of the .wav file where the trigger signal data are stored.
    g. Click **Import Data** to import the data into the tables in the **File Summary** section. If the data are imported successfully. The tables in the **File Summary** section will be updated and a success message will be displayed in the **Data Import Messages** section.

If the data was not imported successfully, error messages will be displayed in the **Data Import Messages** section. See Section 7.1.1 for more information on the messages that are displayed in the **Data Import Messages** section.

3. Repeat step 2 until at least 4 samples for each operating condition are imported, which will enable the **Submit Data** button.
4. Click the **Submit Data** button to submit the data for further analysis or click **Cancel** to discard the data.

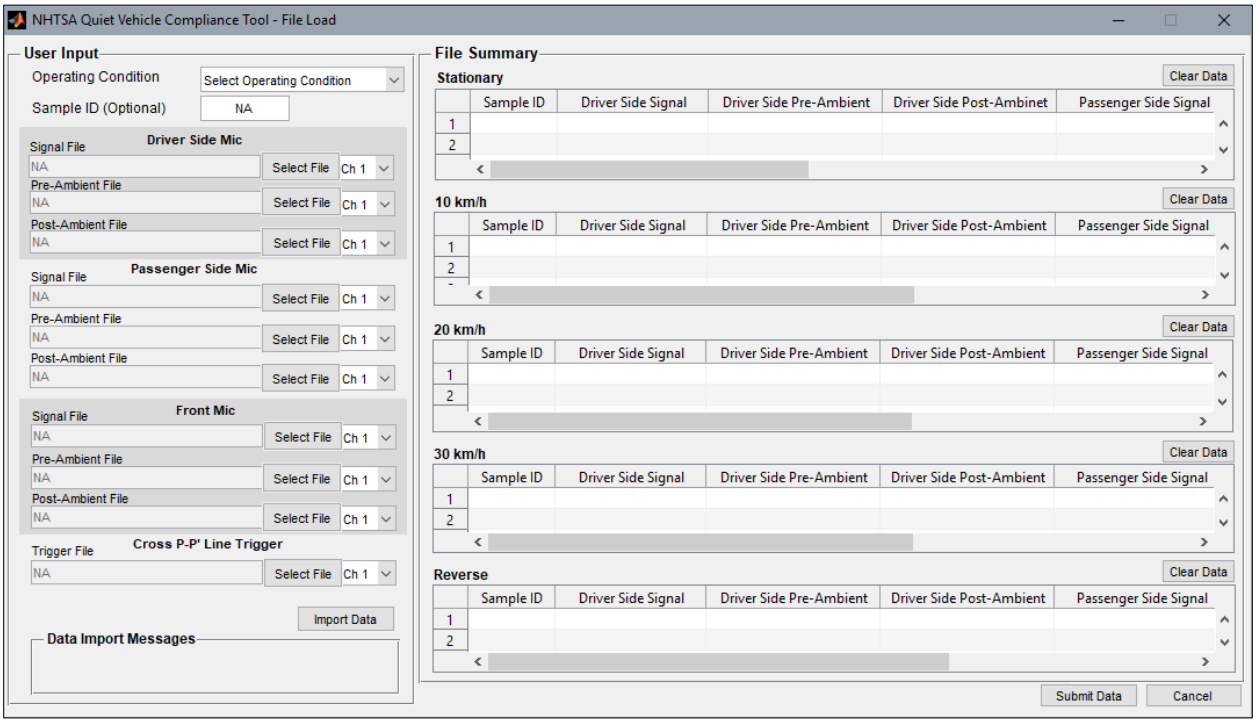

Figure 5: File Load Window

7.1.1 Data Import Messages

Limited error checking is implemented for loading files. Messages will be relayed through the **Data Import Messages** section if the operating condition has not been selected or if a required file has not been selected (Figure 6).

A successful message will also be displayed in the **Data Import Messages** section when the data are imported into the **File Summary** section successfully.

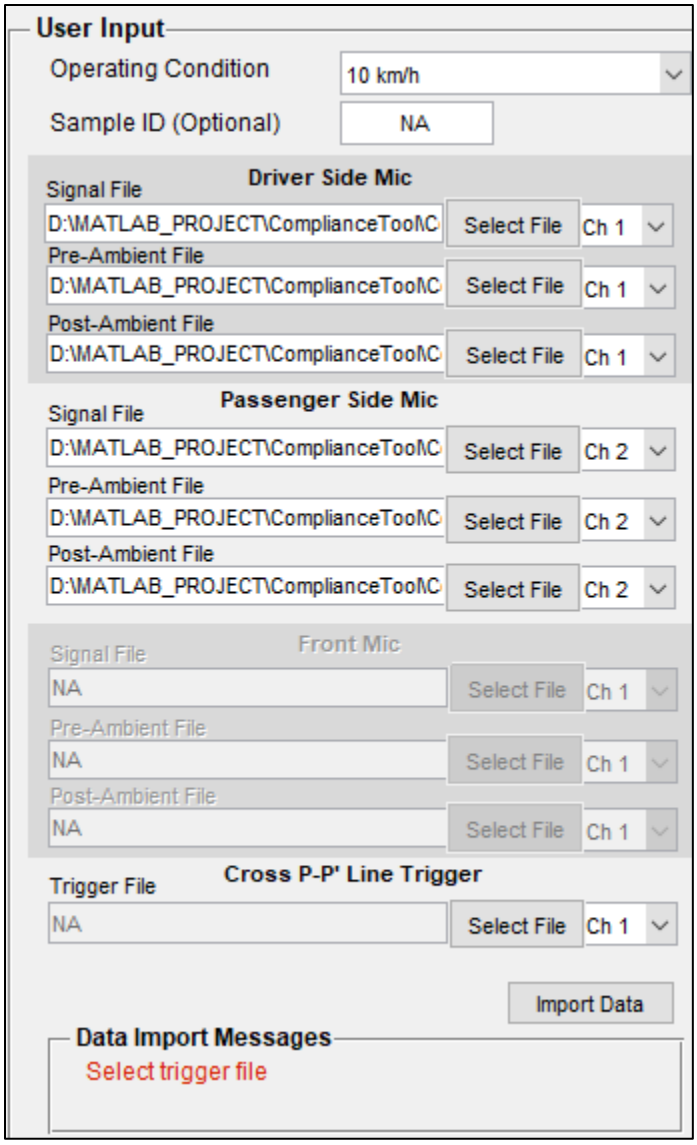

Figure 6: Data Import Error Message Example

7.2 Batch File Load

Loading data in a batch is a faster, but less flexible way of importing the data. The batch process will import all data into the **File Summary** section of the **File Load** window (Figure 5) according to the folder structure and file naming convention described below. Additional files can be imported individually after a batch of files have been imported.

To import by batch:

1. Create a folder according to the folder structure described in Section 7.2.1.
2. Organize the .wav files into the appropriate folders and name the files according to the file naming convention described in Section 7.2.2.
3. Within the Quiet Vehicle Compliance Tool's main window, **File Select** section, select the **Batch File Load** radio button and click **File Select**.

4. Navigate to the top folder of the structure described in Section 7.2.1 (ToyotaCamry in this example) and click **Select Folder** to import the contents of the folder structure and open the **File Load** window.
5. Import additional files individually as described in Section 7.1 if desired.
6. Click the **Submit Data** button to submit the data for further analysis or click **Cancel** to discard the data.

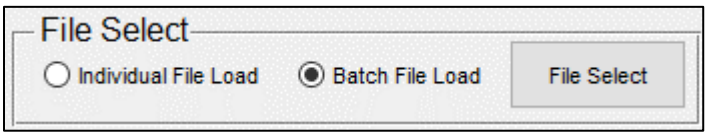

Figure 7: File Select – Batch File Load

7.2.1 Folder Structure

The batch file load expects the following folder structure. If this structure is not followed, an error will appear in the **File Select** section to review the batch folder structure requirements.

Create one folder per vehicle and within that folder include separate folders for each operating condition named “10kmh”, “20 kmh”, “30 kmh”, “Reverse”, and “Stationary”. The folder names are case sensitive. While the batch file load does not expect a particular name of the top most folder, it is recommended to use the vehicle make and model. An example folder structure is shown in Figure 8.

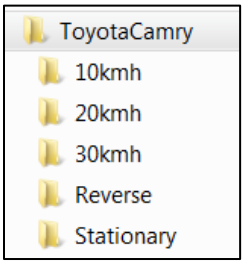

Figure 8: Folder Structure

7.2.2 File Requirements and Naming Convention

File Requirements

The batch file load expects that the following files exist within the folder structure described in Section 7.2.1.

- Pass-by folders (10 km/h, 20 km/h, 30 km/h):
  - 1 pre-ambient file
    - Channel 1: Pre-ambient signal – driver side
    - Channel 2: Pre-ambient signal – passenger side
  - Multiple signal files
    - Channel 1: Driver signal
    - Channel 2: Passenger signal
    - Channel 3: Trigger signal
  - 1 post-ambient file (for driver/passenger)
    - Channel 1: Post-ambient signal – driver side
    - Channel 2: Post-ambient signal – passenger side

- Stationary folder:
  - 1 pre-ambient file
    - Channel 1: Pre-ambient signal – driver side
    - Channel 2: Pre-ambient signal – passenger side
    - Channel 3: Pre-ambient signal – front
  - Multiple signal files
    - Channel 1: Driver signal
    - Channel 2: Passenger signal
    - Channel 3: Front signal
  - 1 post-ambient file
    - Channel 1: Post-ambient signal – driver side
    - Channel 2: Post-ambient signal – passenger side
    - Channel 3: Post-ambient signal – front

- Reverse folder:
  - 1 pre-ambient file
    - Channel 1: Pre-ambient signal – driver side
    - Channel 2: Pre-ambient signal – passenger side
  - Multiple signal files
    - Channel 1: Driver signal
    - Channel 2: Passenger signal
  - 1 post-ambient file
    - Channel 1: Post-ambient signal – driver side
    - Channel 2: Post-ambient signal – passenger side

File Naming Convention
Name all of the files within the operation type folders according to the following convention. The accepted values for each element of the file name are as described in Table 2.

[Test location]_[Collection date]_[Internal tracking number]_ [Make]_[Model]_[Year]_[Vehicle type]_[Operation type]_[Sample ID].wav

Example file name:
VRTC_20170329_ 0507_Ford_Fusion_2010_ICE_30Passby_002.wav

Table 2: File Name Elements

Element	Description	Accepted Values
Test location	User defined	
Collection date	Date	Format: YYYYMMDD
Internal tracking number	Tracking number for user organization	4- digit number
Make	Vehicle make User defined	
Model	Vehicle model User defined	
Year	Vehicle model year	Format: YYYY
Vehicle type	Type of vehicle propulsion	ICE EV HEV
Operation type	Only the specific values listed in the next column are accepted	10Passby 10PreAmbient 10PostAmbient 20Passby 20PreAmbient 20PostAmbient 30Passby 30PreAmbient 30PostAmbient Stationary StatPreAmbient StatPostAmbient Reverse RevPreAmbient RevPostAmbient
Sample ID	Sample number used throughout the analysis	3-digit number

8 Vehicle Information and User Comments

In Area (B), enter the vehicle year, make, model, NHTSA number, and vehicle identification number (VIN), see Figure 9. The information entered into these fields will be used in naming the output files and will be recorded in the Summary Log (Section 11.2).

Note that the vehicle information pictured in Figure 9 does not correspond to the example data that is used throughout this user guide.

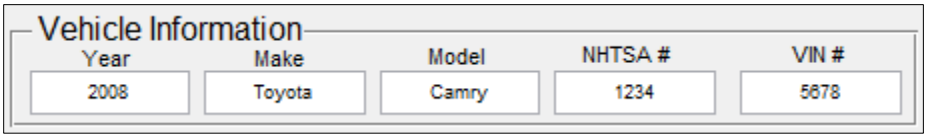

Figure 9: Vehicle Information

In Area (C), enter any comments relevant to the analysis. These comments will be recorded in the Summary Log.

Figure 10: User Comments

9 Data Review

All data will be selected (included) for the analysis unless discarded during the review process. It is recommended to review the data for contamination, such as a spike in the sound pressure before the pass-by occurs, before computing the analysis and discard samples with contaminated data. Review samples by clicking the **Review Next** button and the **Previous** button. Discard a sample from the analysis by clicking the **Discard and Review Next** button.

The default trigger threshold can be changed during the review process. If no changes are made to the trigger threshold during review, the default value of 20% will be used. For more information on setting an appropriate trigger threshold, see Appendix I and Appendix II.

The sound channels and trigger channels can be evaluated in Area (D) as follows:

- **Operating Condition** drop-down menu: Select an operating condition (**Stationary, 10 km/h, 20 km/h, 30/kmh, or Reverse**) to review the first sample associated with the selected operating condition.
- **Sample ID** field: The Sample ID that corresponds to the current sample for the selected operating condition is displayed in the **Sample ID** field.
- **Total samples available for analysis** field: The total number of samples that have been imported and are available for the analysis for the selected operating condition. If samples are discarded, this number is updated to reflect the new total number of samples available for analysis.
- **Driver Side Mic, Passenger Side Mic, Front Mic, and P-P' Line Crossing Trigger** sections: The fields in these sections will automatically populate to display the file names and channel numbers for the sample currently in review.
- **Determine Analysis Region**: When an operating condition is selected or the next or previous sample is viewed, the corresponding data will be automatically plotted in this section with a 1 second delay between files as follows:
    - For all operating conditions the following files are plotted:
        - Driver Side Signal: Signal in dark blue
        - Driver Side Signal: Pre-Ambient in a lighter blue
        - Driver Side Signal: Post-Ambient in the lightest blue
        - Passenger Side Signal: Signal in red
        - Passenger Side Signal: Pre-Ambient in pink
        - Passenger Side Signal: Post-Ambient in a lighter pink
    - For stationary operations the following files are plotted next:
        - Front Signal: Signal in black
        - Front Side Signal: Pre-Ambient in gray
        - Front Side Signal: Post-Ambient in a lighter gray
    - For pass-by operations (Figure 11)
        - The trigger signal file is plotted next in bright green
        - The trigger threshold is plotted in a dashed line and in dark green
            - The trigger threshold is a percentage of the full range
            - Edit the **Trigger Threshold** so that the threshold is first exceeded at the point that the vehicle reaches line A-A'. If a threshold is not entered, then the default value of 20% will be used. Note it is expected that both the trigger at A-A' and P-P' can use the same trigger threshold.

    - The time at which the threshold is exceeded for the trigger at A-A' is displayed in the **Trigger Time** field.
- **Previous Sample:** Click this button to review a previous sample until the desired data are displayed.
- **Discard Sample and Review Next:** If the sample has been contaminated and should be discarded from the analysis, click this button**.** The sample will be removed from the analysis, the number of available samples will be updated in the **Total samples available for analysis** field, the **Reviewing sample** field and the next sample will be loaded for review.
- **Review Next:** If the sample is without contaminants and should be retained for the analysis, click this button to retain the sample and review the next sample.
- **Reviewing sample** field: The number of the sample currently in review is displayed with the total number of samples.

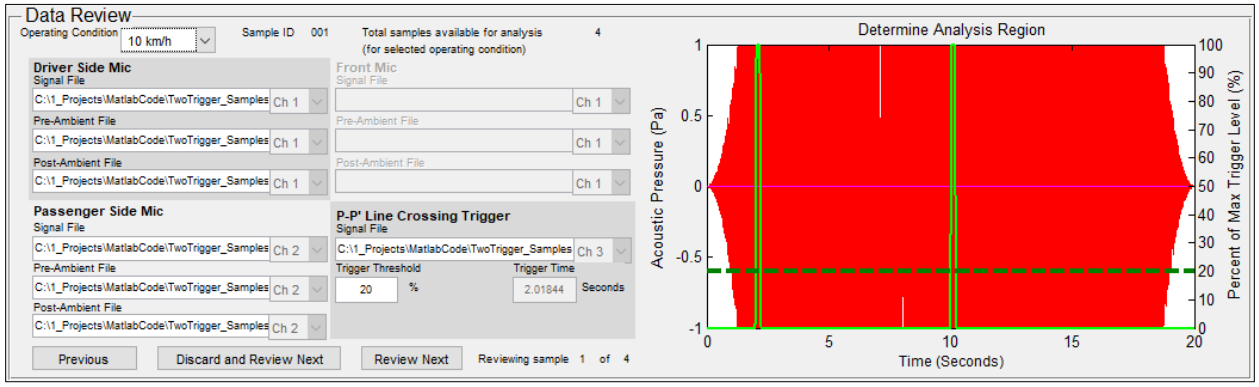

Figure 11: Data Review – Pass-by with Trigger

10 Compute Analysis

After invalid data have been removed and there are at least 4 samples for each operating condition, the analysis can be computed. For more information on the tests that are being conducted during the analysis, see Section 2.3.

Compute and view results in Area (E) as follows:

- Click **Compute Analysis** to begin the analysis.
- Upon clicking **Compute Analysis,** the user will be prompted to select a folder in which to save results. Select a folder or accept the default path. The default output file path is C:\NHTSA\QVCT\Results_[date of analysis]. If this path does not exist, it will be created. The selected file path will be displayed in the **Output File Path** field.
- The following information will be displayed during the analysis and after it has been completed:
    - **Processing Sample:** This field provides updates on the current step in the analysis (Figure 12).
    - **Total Duration:** When the analysis has completed, the total duration will be displayed in this field in seconds (Figure 13).
    - **Stop Analysis:** Click this button at any time during computation to stop the computation. There is a delay between clicking the button and when the analysis is stopped because the tool needs to complete the current task before stopping. The **Stop Analysis** button will be disabled and the **Compute Analysis** button will be enabled, however the analysis has not stopped until a message is displayed in the **Processing Sample** area to confirm when the analysis has been stopped (Figure 14). Note that if the
    - **Output File Path:** The file path where the output files and summary log are stored (Figure 12).

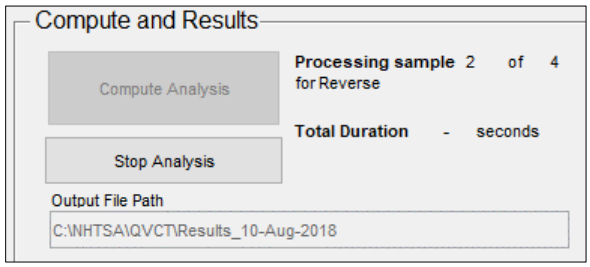

Figure 12: Processing Sample, Output File Path

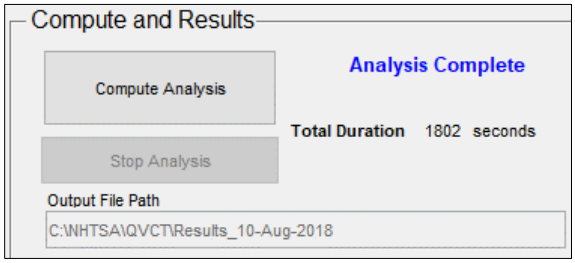

Figure 13: Analysis Complete

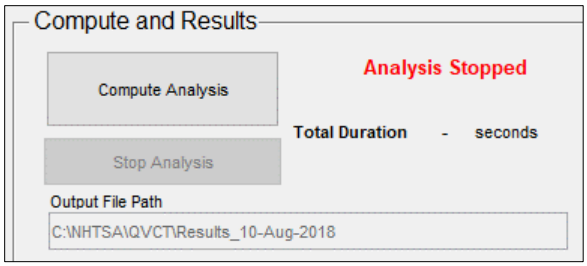

Figure 14: Stop Analysis

- When the analysis has completed, the results table provides a summary of the test results within the analysis. For more information on the tests that are being conducted during the analysis, see Section 2.3.
    - **Driver/Passenger Side Used in Testing:** A record of the lower of the two sides that was used in the analysis.
    - **Passing Combinations: 4-band:** The number of passing combinations for the 4-band test according to section S7.3.5 of the final rule.
    - **Passing Combinations: 4-band Directivity:** The number of passing combinations for the 4-band directivity test according to section S7.1.6 of the final rule.
    - **Passing Combinations: 2-band:** The number of passing combinations for the 2-band test according to section S7.3.5 of the final rule.
    - **Passing Combinations: 2-band Directivity:** The number of passing combinations for the 2-band directivity test according to section S7.1.6 of the final rule.
    - **Band Sum (for Volume Change Analysis):** The normalized band sum according to section S7.6.3 of the final rule.
    - **Overall Test Result:** The overall test result indicates an overall pass or fail status of the compliance test.

Note that the results shown in Figure 15 do not represent real data.

	Reverse	Stationary	10 km/h	20 km/h	30 km/h
Driver/Passenger Side Used in Testing	Driver	Driver	Driver	Driver	Driver
Passing Combos: 4-band	1	1	1	1	1
Passing Combos: 4-band Directivity	-	1	-	-	-
Passing Combos: 2-band	2	1	2	2	2
Passing Combos: 2-band Directivity	-	1	-	-	-
Band Sum (Volume Change Analysis)	-	9.4	15.8	21.8	28.6

Overall Test Result: **Pass** Clear All for New Analysis

Figure 15: Results Table and Overall Test Result

To clear all data in the tool to begin a new analysis, click the **Clear All for New Analysis** button.

11 Output Files

The Quiet Vehicle Compliance Tool outputs the following logs for each analysis in the directory specified upon clicking **Compute Analysis**. The default output file path is C:\NHTSA\QVCT\Results_[Analysis Date].

Six logs are output for each analysis; one for each operating condition, and a summary log. The contents of the logs are described in Sections 11.1 and 11.2. The naming convention for the logs is as follows: [VehicleYear][VehicleMake][VehicleModel][OperatingCondition]_Analysis Number.

The analysis number is automatically generated starting at 1. Each time an analysis is initiated, the analysis number is incremented by 1.

Note that the results shown in this section do not represent real data.

11.1 Output Files Contents

All output files contain at least the following 6 worksheets. The stationary and pass-by output files contain additional worksheets as described in Sections 11.1.1 and 11.1.2.

The output files provide results for each major step in the analysis and can be used to manually verify calculations.

Sheet 1

The **Sheet 1** worksheet contains a summary of the vehicle information and the files that correspond to the lower side that have been selected for further analysis.

Minimum Sound Requirements for Hybrid and Electric Vehicles				
Compliance Tool Version Beta 2				
Log File				
Vehicle Information				
Year	2008			
Make	Toyota			
Model	Camry			
NHTSA #	1234			
VIN	5678			
Operating Condition	10kmh			
Lower Side	Driver			
Samples Input for Testing (Lower Side)	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_
Samples Input for Testing (Lower Side Ambient)	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_
	(Post-Ambient)	(Post-Ambient)	(Post-Ambient)	(Post-Ambient)
Samples Input for Testing (Front)	NA			
Samples Input for Testing (Front Ambient)	NA			
Samples Used in 4 Band and 2 Band Tests (Lower Side)	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_
Samples Used in 4 Band and 2 Band Tests (Lower Side Ambient)	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_	T1_20000101_0000_VMake_VModel_
	(Post-Ambient)	(Post-Ambient)	(Post-Ambient)	(Post-Ambient)
Samples Used in 4 Band and 2 Band Tests (Front)	NA			
Samples Used in 4 Band and 2 Band Tests (Front Ambient)	NA			

Figure 16: Example Output File – Sheet 1

4 Samples

The **4 Samples** worksheet contains the overall and 1/3 octave band (FOB) a-weighted decibel levels for the 4 samples selected for the analysis.

Four samples used in analysis for 2008 Toyota Camry, 10kmh operating condition												
Overall SPL Results - 4 Samples												
Driver Side Vehicle Results (dBA)												
53.1	53.1	53.1	53.1									
Driver Side Ambient Results (dBA)												
31.1	31.1	31.1	31.1									
Passenger Side Vehicle Results (dBA)												
92.5	92.5	92.5	92.5									
Passenger Side Ambient Results (dBA)												
31.1	31.1	31.1	31.1									
FOB Results - 4 Samples												
Driver Side Vehicle Results (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
Driver Side Ambient Results (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
Passenger Side Vehicle Results (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
Passenger Side Ambient Results (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20

Figure 17: Example Output File – 4 Samples

4 Samples Corrected

The **4 Samples Corrected** worksheet contains the overall and 1/3 octave band (FOB) a-weighted decibel levels corrected for the ambient for the 4 samples selected for the analysis.

Four samples used in analysis, corrected for ambient for 2008 Toyota Camry, 10kmh operating condition												
Overall SPL Results Corrected for Ambient - 4 Samples												
Driver Side Vehicle Results - Corrected for Ambient (dBA)												
53.1	53.1	53.1	53.1									
Driver Side Ambient Results (dBA)												
31.1	31.1	31.1	31.1									
Passenger Side Vehicle Results - Corrected for Ambient (dBA)												
92.5	92.5	92.5	92.5									
Passenger Side Ambient Results (dBA)												
31.1	31.1	31.1	31.1									
FOB SPL Results Corrected for Ambient - 4 Samples												
Driver Side Vehicle Results - Corrected for Ambient (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
Driver Side Ambient Results (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
Passenger Side Vehicle Results - Corrected for Ambient (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82
Passenger Side Ambient Results (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20
20	20.2	20.1	20.1	20.1	20.2	20.1	20.1	20.2	20.1	20.1	20	20

Figure 18: Example Output File – 4 Samples Corrected

Averaged

The **Averaged** worksheet contains the overall and 1/3 octave band (FOB) a-weighted decibel levels corrected for the ambient and averaged for the 4 samples selected for the analysis.

Results Corrected for Ambient, Averaged for 2008 Toyota Camry, 10kmh operating condition												
Overall SPL Results - Corrected for Ambient, Averaged												
Driver Side Vehicle Results - Corrected for Ambient, Averaged (dBA)												
53.1												
Passenger Side Vehicle - Corrected for Ambient, Averaged (dBA)												
92.5												
FOB SPL Results - Corrected for Ambient, Averaged												
Driver Side Vehicle Results - Corrected for Ambient, Averaged (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
Passenger Side Vehicle Results - Corrected for Ambient, Averaged (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
79.4	79.7	80.2	79.6	80.7	80.2	81.2	82.4	81.8	82.8	81.7	81.9	82

Figure 19: Example Output File – Averaged

Final Sample

The **Final Sample** worksheet contains the overall and 1/3 octave band (FOB) a-weighted decibel levels corrected for the ambient and averaged for the 4 samples selected for the analysis for the lower side (passenger or driver).

Final Results Corrected for Ambient, Averaged, Lower Side: FINAL RESULT for 2008 Toyota Camry, 10kmh operating condition												
Lower side: Driver												
Final Overall SPL Results Corrected for Ambient, Averaged, Lower Side (dBA)												
53.1												
Final FOB SPL Results Corrected for Ambient, Averaged, Lower Side (dBA)												
315 Hz	400 Hz	500Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5

Figure 20: Example Output File – Final Sample

Operating Condition

The **[Operating Condition]** worksheet contains the band combinations for the 4 band and 2 band tests and a passing or failing status for those bands for that particular operating condition.

10 kmh Condition Samples - Band Combinations

4 Band Test

Bands (Hz)	Averaged Corrected SPL (dBA)	Minimum Requirement (Section S5.1.1.2, Table 1) (dBA)	Difference, dB	4-Band Combination				Pass=1/Fail=0
315	45.5	45	0.5	315	500	800	2000	0
400	33.4	44	-10.6	315	500	800	2500	0
500	46.5	46	0.5	315	500	800	3150	0
630	32.1	46	-13.9	315	500	800	4000	0
800	30.2	47	-16.8	315	500	800	5000	0
1000	30.1	47	-16.9	315	500	1000	2000	0
1250	30.1	48	-17.9	315	500	1000	2500	0
1600	30.2	44	-13.8	315	500	1000	3150	0
2000	34.6	45	-10.4	315	500	1000	4000	0
2500	50.5	43	7.5	315	500	1000	5000	0
3150	34	40	-6	315	500	1250	2000	0
4000	30.3	38	-7.7	315	500	1250	2500	0
5000	36.5	36	0.5	315	500	1250	3150	0
				315	500	1250	4000	0
				315	500	1250	5000	0
				315	500	1600	2500	0
				315	500	1600	3150	0
				315	500	1600	4000	0
				315	500	1600	5000	0
				315	500	2000	3150	0
				315	500	2000	4000	0
				315	500	2000	5000	0
				315	500	2500	4000	0
				315	500	2500	5000	1
				315	500	3150	5000	0
				315	630	1000	2000	0
				315	630	1000	2500	0
				315	630	1000	3150	0
				315	630	1000	4000	0
				315	630	1000	5000	0
				315	630	1250	2000	0

Figure 21: Example Output File – 10 km/h, 4 Band

2 Band Test									
Bands	Averaged Corrected SPL (dBA)	Minimum Requirement (Section S5.2, Table 6) (dBA)	Difference, dB			2-Band Combination		Band Sum for Passing Combinations	Pass=1/Fail=0
315	45.5	42	3.5	Second highest level below 1000 Hz		315	1000	0	0
400	33.4	42	-8.6			315	1250	0	0
500	46.5	42	4.5	Highest level below 1000 Hz		315	1600	0	0
630	32.1	42	-9.9			315	2000	0	0
800	30.2	42	-11.8			315	2500	51.7	1
1000	30.1	42	-11.9			315	3150	0	0
1250	30.1	42	-11.9			400	1000	0	0
1600	30.2	42	-11.8			400	1250	0	0
2000	34.6	42	-7.4	Second highest level between 1000 Hz and 3150 Hz		400	1600	0	0
2500	50.5	42	8.5	Highest level between 1000 Hz and 3150 Hz		400	2000	0	0
3150	34	42	-8			400	2500	0	0
						400	3150	0	0
						500	1000	0	0
						500	1250	0	0
						500	1600	0	0
						500	2000	0	0
						500	2500	52	1
						500	3150	0	0
						630	1000	0	0
						630	1250	0	0
						630	1600	0	0
						630	2000	0	0
						630	2500	0	0
						630	3150	0	0
						800	1250	0	0
						800	1600	0	0
						800	2000	0	0
						800	2500	0	0
						800	3150	0	0

Figure 22: Example Output File – 10 km/h, 2 Band

11.1.1 Directivity (Stationary Output File)

In addition to the 6 worksheets described in Section 11.1, the Stationary output file contains the **Directivity** worksheet. The **Directivity** worksheet contains a pass/fail status for the 4 band and 2 band directivity test. It also contains the a-weighted decibel levels for the directivity test, the a-weighted decibel levels for minimum requirement for the directivity test in the final rule, and the difference. The 4 band and 2 band combinations are listed with a pass/fail status for the directivity test along with the band sum for combinations that pass.

Directivity Results

This vehicle passes the directivity test for both the 4-band test and the 2-band test

4 Band Test

Bands (Hz)	Averaged Corrected SPL (dBA)	Minimum Requirement (Section S5.1.1.2, Table 1) (dBA)	Difference, dB	4-Band Combination				Pass=1/Fail=0
315	79.4	39	0.5	315	500	800	2000	1
400	79.7	39	-7.9	315	500	800	2500	1
500	80.2	40	0.5	315	500	800	3150	1
630	79.6	40	-9.4	315	500	800	4000	1
800	80.7	41	-10.9	315	500	800	5000	1
1000	80.2	41	-10.9	315	500	1000	2000	1
1250	81.2	42	-11.9	315	500	1000	2500	1
1600	82.4	39	-8.9	315	500	1000	3150	1
2000	81.8	39	-7.8	315	500	1000	4000	1
2500	82.8	37	5.5	315	500	1000	5000	1
3150	81.7	34	-3	315	500	1250	2000	1
4000	81.9	32	-1.9	315	500	1250	2500	1
5000	82	31	0.5	315	500	1250	3150	1
				315	500	1250	4000	1
				315	500	1250	5000	1
				315	500	1600	2500	1
				315	500	1600	3150	1
				315	500	1600	4000	1
				315	500	1600	5000	1
				315	500	2000	3150	1
				315	500	2000	4000	1
				315	500	2000	5000	1
				315	500	2500	4000	1
				315	500	2500	5000	1
				315	500	3150	5000	1
				315	630	1000	2000	1
				315	630	1000	2500	1
				315	630	1000	3150	1
				315	630	1000	4000	1
				315	630	1000	5000	1
				315	630	1250	2000	1

Figure 23: Example Output File – Directivity, 4 Band

2 Band Test									
Bands	Averaged Corrected SPL (dBA)	Minimum Requirement (Section S5.2, Table 6) (dBA)	Difference, dB		2-Band Combination		Band Sum for Passing Combinations	Pass=1/Fail=0
315	79.4	40	39.4		315	1000	82.8	1
400	79.7	40	39.7		315	1250	83.4	1
500	80.2	40	40.2	Second highest level below 1000 Hz	315	1600	84.2	1
630	79.6	40	39.6		315	2000	83.8	1
800	80.7	40	40.7	Highest level below 1000 Hz	315	2500	84.4	1
1000	80.2	40	40.2		315	3150	83.7	1
1250	81.2	40	41.2		400	1000	83	1
1600	82.4	40	42.4	Second highest level between 1000 Hz and 3150 Hz	400	1250	83.5	1
2000	81.8	40	41.8		400	1600	84.3	1
2500	82.8	40	42.8	Highest level between 1000 Hz and 3150 Hz	400	2000	83.9	1
3150	81.7	40	41.7		400	2500	84.5	1
					400	3150	83.8	1
					500	1000	83.2	1
					500	1250	83.7	1
					500	1600	84.4	1
					500	2000	84.1	1
					500	2500	84.7	1
					500	3150	84	1
					630	1000	82.9	1
					630	1250	83.5	1
					630	1600	84.2	1
					630	2000	83.8	1
					630	2500	84.5	1
					630	3150	83.8	1
					800	1250	84	1
					800	1600	84.6	1
					800	2000	84.3	1
					800	2500	84.9	1
					800	3150	84.2	1

Figure 24: Example Output File – Directivity, 2 Band

11.1.2 Relative Volume (Pass-by Output Files)

In addition to the 6 worksheets described in Section 11.1, the pass-by output files contain the **Relative Volume** worksheet. The **Relative Volume** worksheet contains an overall status of the relative volume test. It also contains the a-weighted decibel levels for the relative volume test for two operating conditions, the a-weighted decibel levels for minimum requirement for the relative volume test in the final rule, the normalized levels (the operating condition signal – requirement), the normalized band sum for each operating condition, and the relative volume change between the two operating conditions.

The 10 km/h output file contains the comparison between the Stationary and 10 km/h operating conditions. The 20 km/h output file contains the comparison between the 10 km/h and 20 km/h operating conditions. The 30 km/h output file contains the comparison between the 20 km/h and 30 km/h operating conditions.

Relative Volume Results													
This vehicle passes the relative volume test for the Stationary and 10 kmh operating conditions													
	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
Averaged Corrected SPL, Stationary, dBA	39.5	31.1	40.5	30.6	30.1	30.1	30.1	30.1	31.2	42.5	31	30.1	31.5
Averaged Corrected SPL, 10 kmh, dBA	45.5	33.4	46.5	32.1	30.2	30.1	30.1	30.2	34.6	50.5	34	30.3	36.5
Minimum Requirement (Stationary, Section S5.1.1.2, Table 1), dBA	39	39	40	40	41	41	42	39	39	37	34	32	31
Normalized SPL = Stationary SPL - Requirement, dB	0.5	-7.9	0.5	-9.4	-10.9	-10.9	-11.9	-8.9	-7.8	5.5	-3	-1.9	0.5
Normalized Signal = 10 kmh Level - Requirement, dB	6.5	-5.6	6.5	-7.9	-10.8	-10.9	-11.9	-8.8	-4.4	13.5	0	-1.7	5.5
Normalized Band Sum, Stationary, dBA	9.5												
Normalized Band Sum, 10 kmh, dBA	15.8												
Relative Volume Change Between Stationary and 10 kmh, dB	6.3												

Figure 25: Example Output File – Relative Volume (10 km/h)

11.2 Summary Log

The summary log provides an overall summary of the analysis. The vehicle information and user comments are recorded on the left side of the log. The results are recorded for each test and operating condition along with the lower side and number of passing bands (for 4 and 2 band tests). The Relevant Signal Files are the lower side (driver or passenger), and the front signal files. The overall test result is also recorded in the summary log.

Note that the results shown in this section do not represent real data.

NHTSA

Minimum Sound Requirements for Hybrid and Electric Vehicles IAW 49 CFR § 571.141
Quiet Vehicle Compliance Tool - Summary Log

Testing Data		Operating Conditions	4 Band (S5.1)		2 Band (S5.2)		Test Result	Relative Volume Change (S5.4)	Low Side Location	Relevant Signal Files
Vehicle Information			# of Passing Band	Result	# of Passing Band	Result	Best Result of 4 OR 2 Band Columns			
Year	2008	**1.** Stationary	1	Pass	1	Pass	Pass		Driver	T1_20000101_(T1_20000101_(T1_20000101_(T1_20000101_(
Make	Toyota	└ Directivity	185	Pass	29	Pass	Pass		Front	T1_20000101_(T1_20000101_(T1_20000101_(T1_20000101_(
Model	Camry	**2.** Reverse	1	Pass	2	Pass	Pass		Driver	T1_20000101_(T1_20000101_(T1_20000101_(T1_20000101_(
NHTSA No.	1234	**3.** 11 km/h +/- 1	1	Pass	2	Pass	Pass	Pass	Driver	T1_20000101_(T1_20000101_(T1_20000101_(T1_20000101_(
VIN	5678	**4.** 21 km/h +/- 1	1	Pass	2	Pass	Pass	Pass	Driver	T1_20000101_(T1_20000101_(T1_20000101_(T1_20000101_(
		5. 31 km/h +/- 1	1	Pass	2	Pass	Pass	Pass	Driver	T1_20000101_(T1_20000101_(T1_20000101_(T1_20000101_(
User Comments		*Optional Tests*								
Sample for User Guide		*6. Between 10-20 km/h*								
		7. Between 20-30 km/h								
					OVERALL RESULT		Pass			

Quiet Vehicle Compliance Tool Version: Beta 2

Figure 26: Summary Log Example

Appendix I: Detailed Data Evaluation

Additional information on evaluating data is described in this section.

Selecting the Trigger Threshold

The trigger threshold should be set so that the threshold is first exceeded at the point that the vehicle reaches the microphone line. A pass-by analysis includes the region from the start of the measurement to when the trigger threshold is reached for the first time. The maximum level in this region is used to compute the SPL of the event. Additional discussion of triggers is given in Appendix II.

Pass-by Time Signal Shape

The shape of the pass-by time signal is expected to look similar to Figure 27, where there is a period of time where the sound pressure is low and increases as the vehicle approaches the microphone line and then decreases as the vehicle departs. In this example, there is a dip in the level while the vehicle is passing the microphone line. The presence of a dip is not an indication of a good or bad measurement, but reflects characteristics of the particular vehicle's sound source(s). For example, a dip could occur if there is a dominant source in both the front and rear of the vehicle; it could be due to the source's directivity; or it could occur due to a modulation in the emitted signal. Figure 27 also shows a red line with arrows pointed to the left. This line coincides with the time when the trigger threshold is exceeded. Only the region to the left of the red line is included in the analysis.

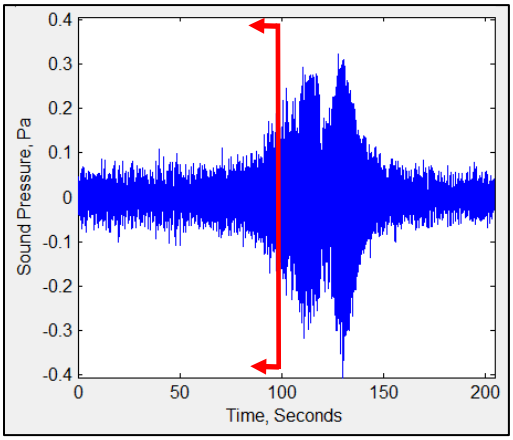

Figure 27: Example of Time Series Display of a Pass-by Driver Side Sound Signal. The vertical line with arrows indicates the analysis region based on a 20% trigger threshold.

Stationary Time Signal Shape

The shape of the stationary time signal is expected to look similar to Figure 28, where there is variation on a very short time scale, e.g. multiple peaks occurring within a single second, but the average level is generally the same over the measurement period. Note, that in contrast to the pass-by analysis that looks at the time history prior to exceeding the trigger threshold, analysis for this type of operation uses the first 10 seconds of the measurement.

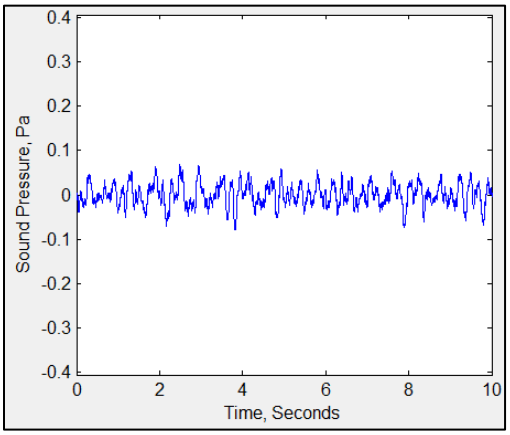

Figure 28 - Example of Time Series Display of a Stationary Driver Side Sound Signal

Reverse Time Signal Shape

The shape of the reverse time signal is expected to look similar to Figure 29, where there is variation on a very short time scale, e.g. multiple peaks occurring within a single second, but the average level is generally the same over the measurement period. Note, that in contrast to the pass-by analysis that looks at the time history prior to exceeding the trigger threshold, analysis for this type of operation uses the first 10 seconds of the measurement.

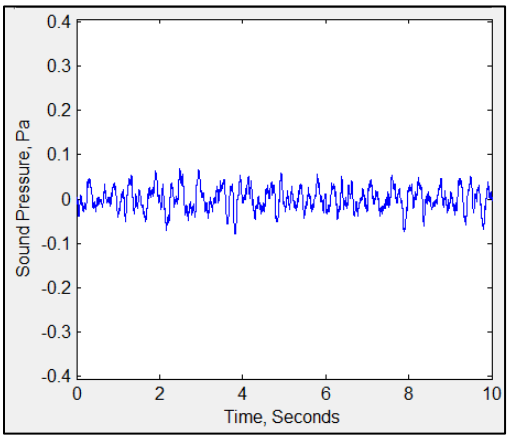

Figure 29 - Example of Time Series Display of a Reverse Driver Side Sound Signal

Appendix II: Triggers

A trigger is a secondary signal that indicates when an event occurs. There are many types of triggers for a wide range of applications and it is not practical to review the topic exhaustively. For the purposes of this user guide, triggers will be discussed as they relate to detecting the time when a moving vehicle crosses a line formed by two microphones on either side of the vehicle's path. Two triggers are expected to exist at line A-A' and P-P' as shown in Figure 30. The compliance tool computes the time varying sound pressure level from the start of the signal file; however, it only looks for maximum or minimum sound pressure levels between the two trigger events. That is if a minimum or maximum occurs before the first trigger or after the second trigger, it will not be considered. Only the maximum and minimum between the triggers is considered. This prevents unwanted transient effects associated with the filters to be rejected during the analysis.

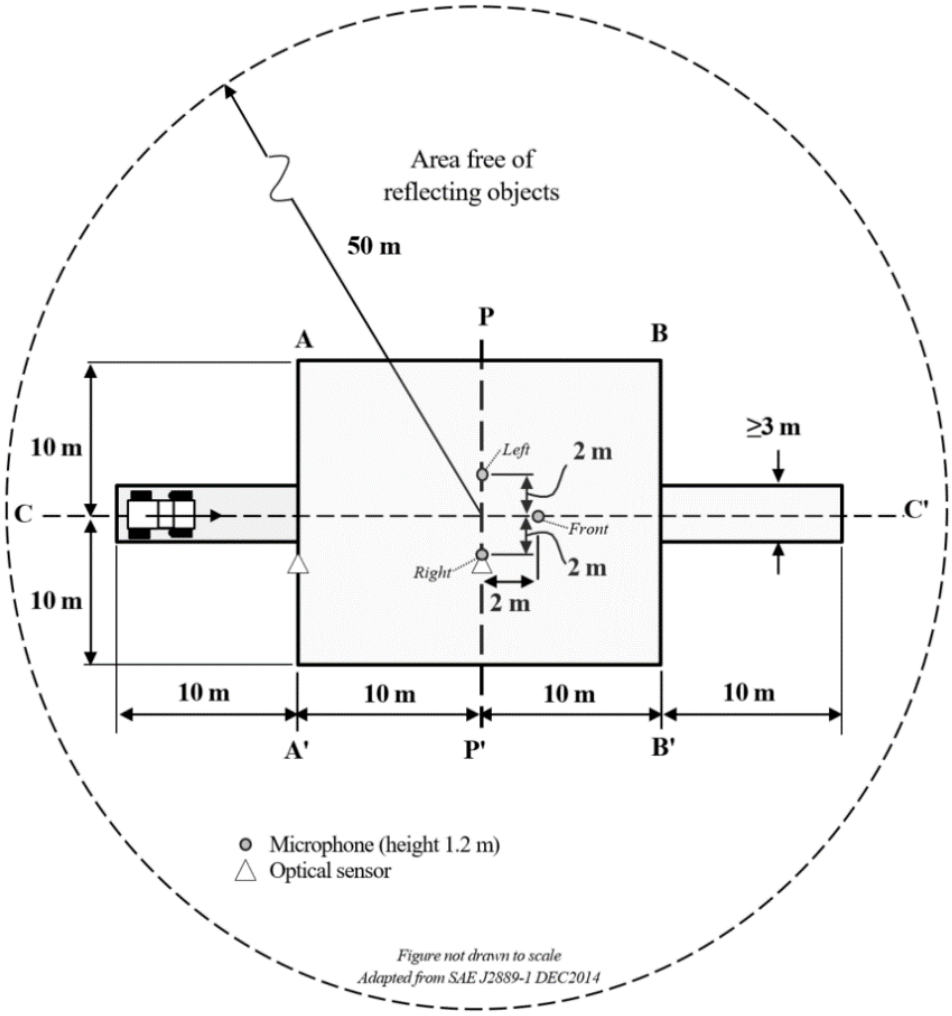

Figure 30: Test Site Dimensions adapted from SAE J2889-1[4] Modifications include addition of a front microphone used only during stationary/directivity measures and optical sensors to record trigger signals for pass-by tests.

[4] The test protocol follows procedures in SAE J2889-1 (December 2014), *Measurement of Minimum Noise Emitted by Road Vehicles*

There are many different methods of generating a trigger signal and each has unique characteristics. For example, trigger signals can be generated from:

- pneumatic or mechanical pressure plates (activated by compressing or uncompressing the sensor),
- proximity sensors (activated by approaching or moving away from the sensor), or
- photodetectors (activated by changing the state of line-of-sight as either broken or unbroken).

When a sensor is activated it will typically either produce a short signal, a quick rise and fall of the voltage (see Figure 31), or it will produce a steady state change in the voltage from one state to another (see Figure 32). In either case, there can be a non-zero voltage present before the trigger is activated and there can be noise on the signal when the sensor is activated. Both noise and a non-zero rest state mean that, in order to identify when the trigger is truly active, one needs to set a threshold that must be exceeded to consider the trigger activated. The drawback to setting a threshold is that it can induce a delay to the detection of the event due to the rise-time of the sensor.

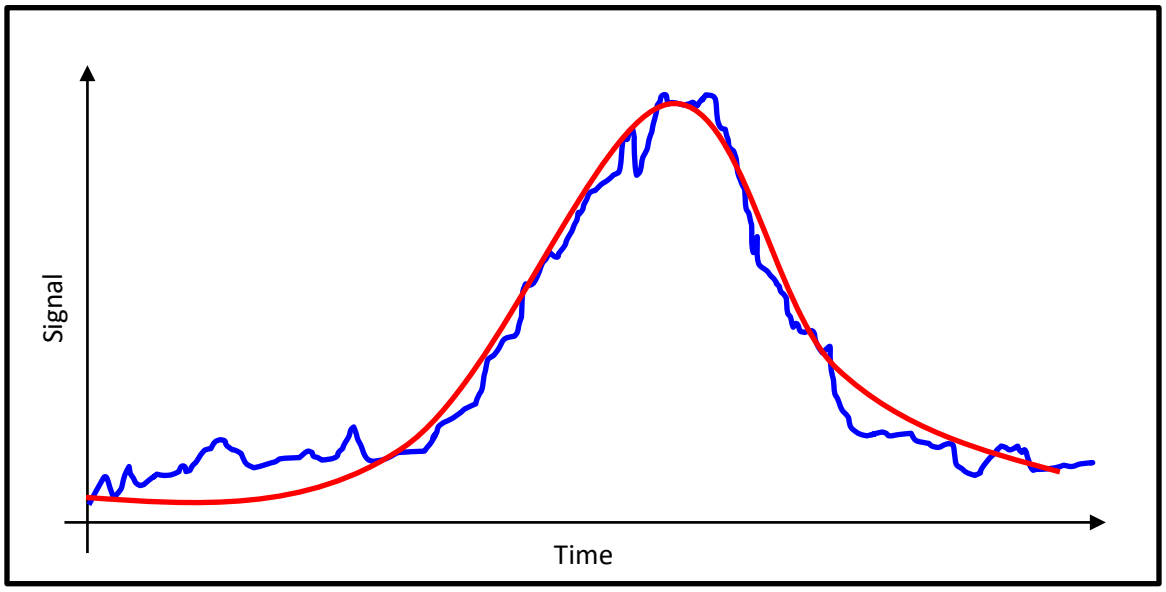

Figure 31: Example of Transient Trigger Signal. Idealized Signal in Red. Typical Signal in Blue.

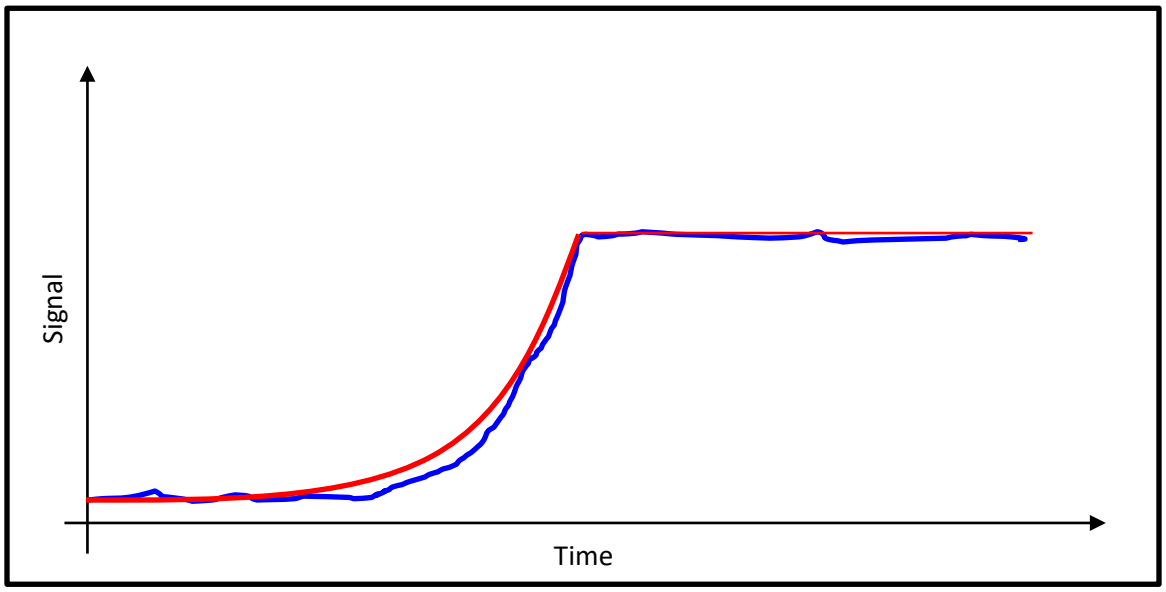

Figure 32: Example of a Steady State Trigger Signal. Idealized Signal in **Red**. Typical Signal in **Blue**.

General guidelines for optimizing trigger thresholds are shown in Table 3.

Table 3: Optimizing Trigger Threshold to Account for Trigger Signal Characteristics

To Mitigate	Set Threshold
Noisy Signal	Higher
Non-Zero Rest State	Higher
Slow Rise-Time	Lower

An example of a trigger signal, zoomed in to show multiple peaks in the signal is shown in Figure 33. It is important to set the trigger according to the first peak.

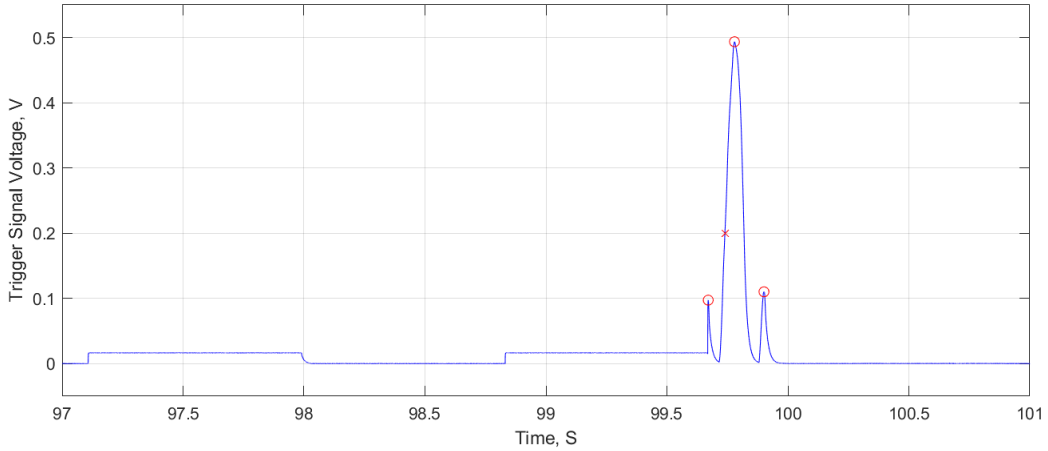

Figure 33: Example of a Trigger Signal, Zoomed In.

Appendix III: Data Processing

The Quiet Vehicle Compliance Tool was developed to be used by the test technician after execution of all test series (i.e., stationary, reverse, and pass-by tests) have been completed to automate signal analysis.

Figure 34 is a flow diagram depicting the process used by the tool to determine if four valid test runs within 2.0 dB have been completed.

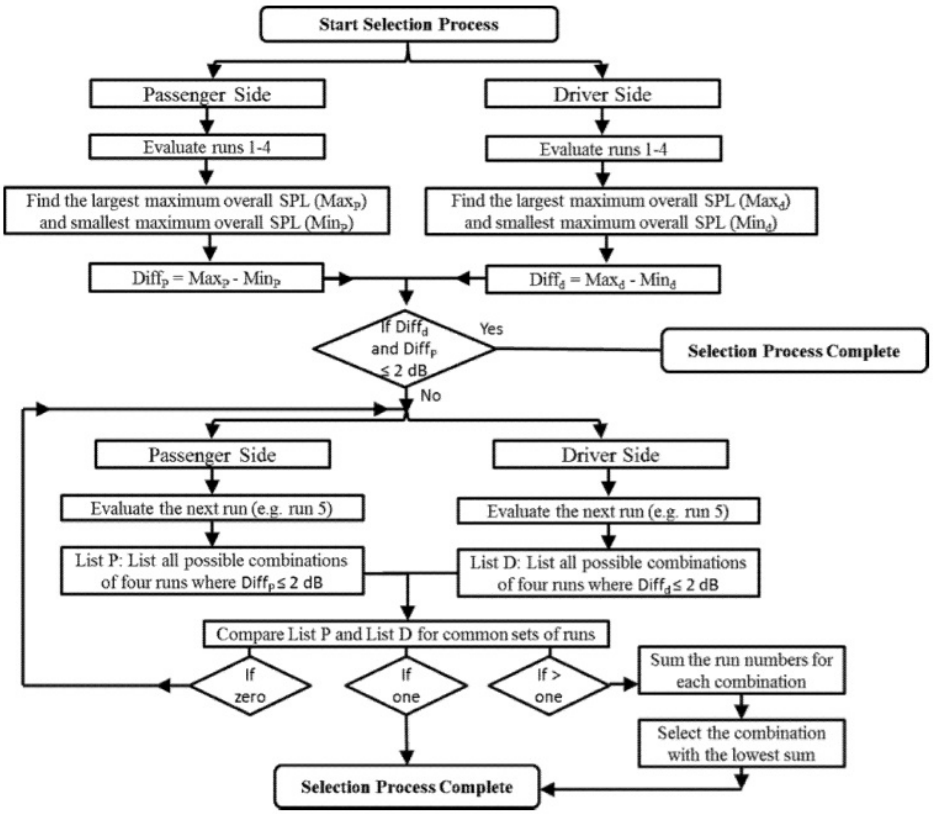

Figure 34 Selection process to determine first four valid test runs within 2.0 dBA

For each test run, a valid left (driver's side) and a valid right (passenger side) sound recording must exist. For each side, the maximum overall SPL must be determined. The four test runs to be used for the compliance evaluation are the first four valid test runs collected that have four left side signals within 2.0 dBA maximum overall SPL and four right side signals within 2.0 dBA maximum overall SPL. The left and right side must come from the same set of four test runs.

The test run selection process is depicted in Figure 34, and subsequent steps are as follows (Step 1 is a manual process, but steps 2 through 20 can be completed by the technician or by using the Quiet Vehicle Compliance Tool):

Step 1: The technician numbers each valid sound measurement test run sequentially in the chronological order it was completed on the test track– e.g., Run 1, Run 2, Run 3, … Run N. Each test run

must have a file or files corresponding to the left (driver's side) and right (passenger side) acoustic sound signals.

Step 2: Determine the maximum overall SPL value for the left and right side sound signals from each of the first 4 test runs.

Step 3: Compare the first four left side (driver's side) maximum overall SPL values. Calculate the difference between the largest and smallest of the four values. Use the same process to determine the difference between the largest and smallest of the first four right side (passenger side) maximum overall SPL values. If the difference is less than or equal to 2.0 dBA on both the left and right sides, then these four test runs will be used for the compliance evaluation, and the test run selection process for the given operating condition is complete and the selected runs will be considered the "first four valid test runs within 2.0 dBA." If selection is not considered complete, continue to Step 4. If selection is considered complete skip to step 10, where additional processing steps continue. [i]

Step 4: Include data from the next sequential run.

Step 5: For the driver-side microphone, list all possible combinations of four runs for which the largest overall SPL from any of the four runs minus the smallest overall SPL from any of the four runs is less than or equal to 2.0 dBA.

Step 6: For the passenger-side microphone, list all possible combinations of four runs for which the largest overall SPL from any of the four runs minus the smallest overall SPL from any of the four runs is less than or equal to 2.0 dBA.

Step 7: Examine the list of runs developed in both Step 5 and Step 6. If a set of four runs (e.g., Run 1, Run 2, Run 4, and Run 5) appears in both the Step 5 and Step 6 lists, enter it into a new list (the Step 7 List).

Step 8: The Step 7 list can possibly contain zero, one, or two entries. If the Step 7 list has zero entries, return to step 4. If the Step 7 list contains exactly one entry, then that entry is the list of runs for which final data will be analyzed. For this case, terminate the run selection procedure. This list of runs will be considered the "first four valid test runs." If the Step 7 list contains more than one entry, go on to Step 9.

Step 9: Case for which the Step 7 list contains more than one entry. Sum the run numbers for each entry in the Step 7 list. For example, if an entry contains Run 1, Run 2, Run 4, and Run 5, then the sum of its run numbers would be 12 (1+2+4+5). Select the entry with the lowest sum of its run numbers. This set of runs is the set for which final data will be analyzed for compliance. At this point, terminate the run selection procedure. This set of runs will be considered the "first four valid test runs within 2.0 dBA." [ii]

Step 10: After the ''first four valid test runs within 2.0 dBA'' have been identified for each test series, the four acoustic sound files from each side of the vehicle recorded during those four runs are analyzed to determine which side of the vehicle was the quietest during test execution (see Figure 35). For each of the eight acoustic sound data signals (four left side signals and four right side signals) the maximum

overall SPL value is determined (i.e., For the stationary tests the maximum overall SPL value measured any time during each 10 sec sound signals. For the pass-by tests the maximum overall SPL value recorded any time between AA' and PP', up to and including PP', during each sound signals.)

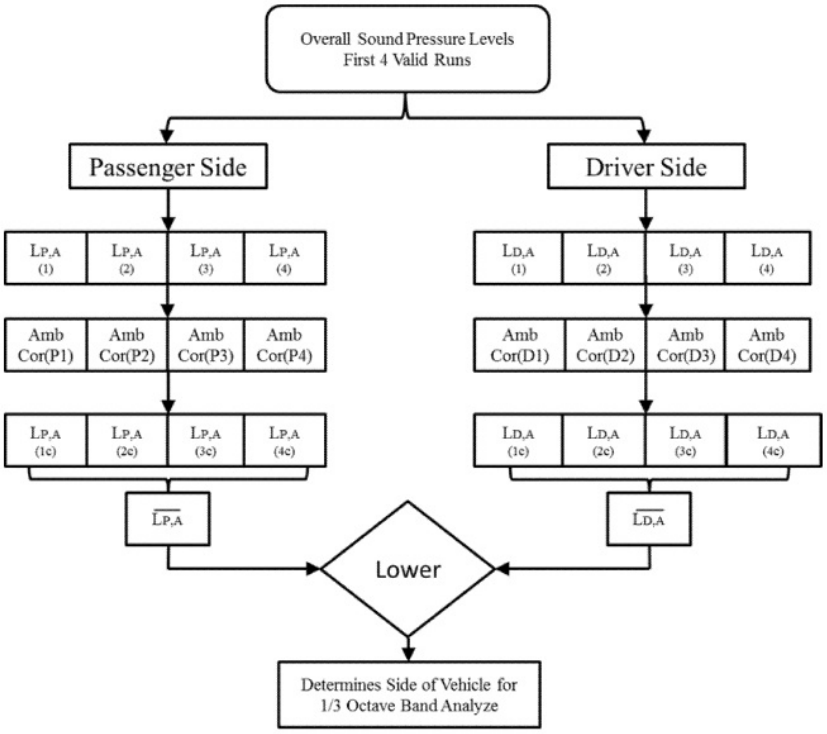

Figure 35 Flow diagram for identification of quietest side of test vehicle to be used for one-third octave analysis

Step 11: Each of the eight acoustic signal maximum overall SPL values are then corrected for the recorded ambient conditions as specified in the standard (see FMVSS 141, S6.7).

Step 12: Finally, the four ambient-corrected maximum overall SPL values on each side of the vehicle are linearly averaged together for one comprehensive ambient-corrected value for each side of the vehicle.

Step 13: The side of the vehicle with the lowest average ambient-corrected maximum overall SPL value is the side of the vehicle that is further evaluated for compliance at the one-third octave band level. Each of the four acoustic signals on the side of the vehicle with the lowest average ambient-corrected maximum overall SPL value are then used for the one-third octave band evaluation as depicted in the flow diagram in Figure 36.[iii]

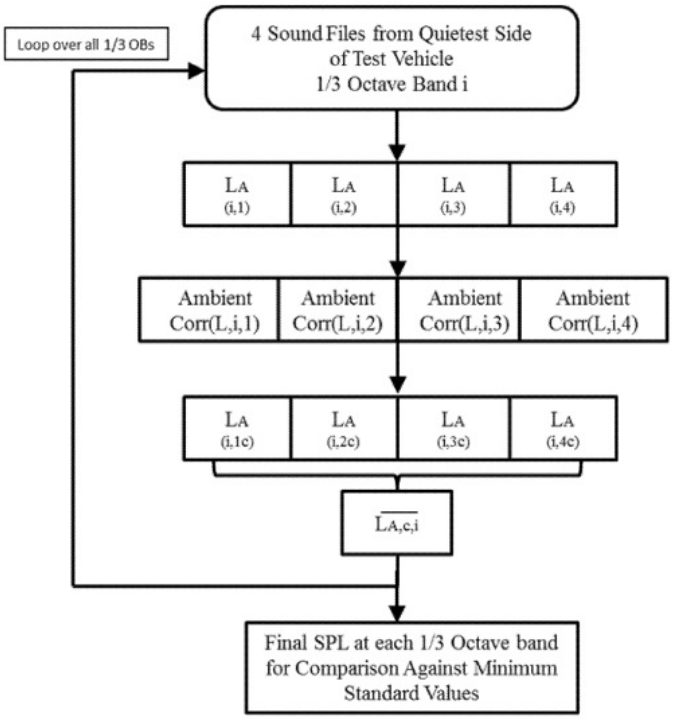

Figure 36 Flow diagram for processing sound files at one-third octave band levels

Step 14: Figure 36 indicates the flow process for analyzing the selected four acoustic signals for the one-third octave band analysis. As shown in Figure 35, the side of the vehicle found to have the lowest overall SPL value, corrected for ambient and averaged over four runs, is the side of the vehicle that is further evaluated for compliance verification. The side selected has four individual acoustic signals. Each signal is broken down into one-third octave band levels. **NOTE: The one-third octave band levels to be used for compliance are the levels corresponding to the point in time of the maximum overall sound pressure level of a vehicle measurement. To clarify, for NHTSA's compliance evaluations, the agency will not use the maximum sound pressure level in each one-third octave band if the maximum occurs at any other point over the measurement time interval.**

Step 15: The identified one-third octave band levels in each of the four signals are then corrected for the measured ambient levels as specified in the standard (see FMVSS 141, S6.7). **NOTE: For ambient correction purposes, the ambient one-third octave band levels are the levels at the point in time of the minimum overall ambient sound pressure level.**

Step 16: The four corrected values in each one-third octave band are then averaged together to get the average corrected sound pressure level in each one-third octave band. The averaged corrected values in each one-third octave band are then compared directly to the minimum standards specified in the standard to determine compliance. For the stationary test condition, ''first four valid test runs within 2.0 dBA'' also has front microphone acoustic data. Each sound signal for the front microphone is broken down into its one-third octave band levels. The identified one-third octave band levels in each of the four signals are then corrected for the measured ambient levels as specified in the standard. The four values calculated in each one-third octave band are then averaged together to get the average ambient-corrected sound pressure level in each one-third octave band. The averaged, corrected values in each one-third octave band are then compared directly to the minimum standards specified in this standard

to determine compliance.

Step 17: Utilizing the average corrected one third octave band levels in each of the 13 one-third octave bands from the side of the vehicle with the lowest maximum overall sound pressure level averaged over the four runs for each operating scenario (i.e., stationary, 10 km/h (11+/- 1km/h), 20 km/h (21+/- 1km/h), and 30 km/h (31+/- 1km/h)), calculate the normalized values for each of the 13 one-third octave bands for each of the operating scenarios, relative to the minimum SPL requirements specified for the stationary operating scenario. The normalized values are calculated by subtracting the minimum SPL values specified for the stationary operating condition from each of the one-third octave band averages calculated for each operating scenario (stationary, 10 km/h (11+/- 1km/h), 20 km/h (21+/- 1km/h), and 30 km/h (31+/- 1km/h)).

Step 18: Calculate the NORMALIZED BAND SUM for each critical operating scenario (stationary, 10 km/h (11+/- 1km/h), 20 km/h (21+/- 1km/h), and 30 km/h (31+/- 1km/h)) as follows:

$$Normalized\ Band\ Sum = 10\log_{10}\left(\sum_{i=1}^{13} 10^{\frac{Normalized\ Band\ Level_i}{10}}\right)$$

Where: i represents each of the 13 one-third octave bands and Normalized Band $Level_i$ is the calculated normalized value for each of the 13 one-third octave bands.

Step 19: Calculate the relative volume change between each operating scenario (stationary to 10 km/h; 10 km/h to 20 km/h; 20 km/h to 30 km/h) by subtracting the BAND SUM of the lower speed test case from the BAND SUM of the next higher speed test case.

---

[i] In NHTSA's experience, there have been instances in which it was necessary to examine data from as many as seven runs to find a set of four that are shared by the driver's and passenger's sides that have Overall SPL's that are within 2.0 dBA. Additionally, although data recorded by the front microphone are not considered when determining the "first four valid test runs within 2.0 dBA," those data are used when evaluating compliance with the directivity requirement. The front microphone data to be used for directivity are the data recorded during the "first four valid test runs within 2 dBA" determined according to the procedure above.

[ii] When there are five runs being considered, it is mathematically impossible for the sums of the run numbers for the two entries in the Step 7 list to be exactly the same. One entry will always have a lower value. However, NHTSA has seen cases in which six or seven test runs are needed to find a set of four shared by the driver's and passenger's sides that have Overall SPL's within 2.0 dBA. It might be possible in these situations for the sums of the run numbers for the two entries in the Step 7 list to be exactly the same. If this condition occurs, the procedure will be to eliminate the combination of four runs containing the highest run number. If the highest run number is the same in both four-run combinations, then will eliminate the combination of four runs with the second highest run number, and so on.

[iii] In the event that the average corrected maximum overall SPL values for the driver's and passenger's sides are exactly equal, then the sound from the passenger's side will be analyzed.