

AUTOMOTIVE APPLICATION

# Exhaust Noise Testing



**ACOUSTIC  
SENSORS  
FOR PREMIUM  
NVH DATA**



# Exhaust Noise Testing



The exhaust noise from vehicles with internal combustion engines is very important. It must support a good engine sound quality while not being disturbing or violating noise legislation. The intake system and exhaust system are highly responsible for the engine noise character and sound pressure level (SPL) and must be tuned to meet the required performance. The engine

sound quality should provide driver information about engine rpm as well as a suitable sound for the vehicle type, e.g. powerful and sporty during acceleration, but silent during constant speed driving. This also applies to the exterior sound where the sound character should match the vehicle brand identity.

## ACOUSTIC TEST TYPES WITHIN EXHAUST NOISE TESTING

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### Sound transmission loss (measurements on dynamometer and test rig)

The sound transmission loss of the exhaust system in whole or partly is verified in a sound transmission loss test. This rig basically includes four microphones, a power amplifier with speaker as excitation source, the object to be tested, and an anechoic termination at the downstream end. This testing is done at the component supplier or the OEM. The result is used for verification of requirements and benchmarking, computer-aided engineering (CAE) correlation and during development.

The radiated noise from the exhaust system parts and the tailpipe noise is measured on a full vehicle in a hemi-anechoic test cell with noise, vibration and harshness (NVH) chassis dynamometer. This is important for verification and benchmarking and for understanding the source contribution both for vehicle interior and pass-by noise. The microphones are placed in the near field of the muffler or other parts to be investigated.

Microphones for the tailpipe noise are most often placed at an angle to avoid the direct exhaust flow. Probe microphones should be used, if the microphone needs to be in the exhaust flow or in the proximity of a very hot part. Sound pressure levels and engine orders versus engine rpm are analyzed.

Acoustic transfer function (ATF) measurements from the exhaust pipe to the vehicle interior are used to verify the acoustic package and to validate CAE models, but can also as be used as one of several inputs for vehicle simulators where sound quality design targets can be evaluated subjectively at an early stage before hardware is available.

### Pass-by noise

The pass-by noise measurement is the critical final testing to verify that the legislation requirements can be met and, if not, to find the main source of the problem. This is done on a dedicated test track as per global standards. Additional muffling for the exhaust system can be used to understand, if the tailpipe noise is the problem.

Indoor pass-by noise is used for development and requires a very large hemi-anechoic chamber and a microphone array on each side of the vehicle to simulate the actual pass-by. For source contribution analysis, the ATF from the exhaust system to these microphones needs to be measured.



## CHALLENGES COMMON TO EXHAUST NOISE TESTING

The hot and dusty environment must be considered for measurement setup and equipment selection. Other important issues are exact positioning of microphones to be able to verify calibration before testing. The environmental conditions during the operational measurements are harsh with heat, dust, humidity and exhaust flow. The transducers are often moved to different positions so they must withstand handling and occasionally being dropped to the floor. It is also important to be able to position the microphones precisely and thus verify calibration before testing.



## SELECTING THE RIGHT MICROPHONE

### Sound transmission loss (measurements on dynamometer)

The operating measurements are done with ruggedized ½" pressure or free-field microphones as per the company standards. For extremely hot positions close to e.g. the exhaust catalyst or in the direct exhaust flow, use a probe microphone. Windshields are recommended both to minimize wind noise and to provide some microphone protection.

The 146AE ½" CCP Free-field Microphone Set can be mounted in the near field of the muffler using the AL0004 Small, Lightweight Microphone Tripod in combination with the RA0093 ½" 5-click Microphone Holder or the AL0008 ½" Microphone Holder. The AL0008 also requires the use of the AL0005 Swivel Head.

The 146AE can also be used for tailpipe noise measurements. Its special filter in the protection grid and overall rugged design can withstand the high temperatures and high velocity particles from the exhaust system.

The RA0504 GoPro Adaptor will help to ensure quick and easy positioning of the 146AE microphone on the car's tailpipe. The adaptor is also applicable for mounting of any other ½" measurement microphone and can be used on the wide variety of GoPro tripods, mounts and clamps available on the market.

The AM0069 Spherical Windscreen for ½" Microphones can be mounted on the 146AE microphone for in-flow measurements.

When temperatures exceed 125 °C (257 °F), a probe microphone like the 40SC CCP Probe Microphone can be used for exhaust noise measurements, even with the microphone placed in flow.

The 42AG Multifunction Sound Calibrator can be used for daily sensitivity verification of the measurement microphones.

### RECOMMENDED MICROPHONES AND CALIBRATORS

#### Sound Transmission Loss (Measurements on Dynamometer)

Test cell	146AE	½" CCP Free-field Microphone Set
	40SC	CCP Probe Microphone
	AL0004	Small, Lightweight Microphone Tripod
	AL0005	Swivel Head
	AL0008	½" Microphone Holder, POM
	RA0093	½" 5-click Microphone Holder, Stainless Steel
	AM0069	Spherical Windscreen for ½" Microphones
	RA0504	GoPro Adapter
Calibration	42AG	Multifunction Sound Calibrator, Class 1

### Sound transmission loss (test rig)

A sound transmission loss rig for exhaust systems typically uses four class 1 ¼" microphones.

The 46BD-FV ¼" CCP Pressure Standard Microphone Set can be used as a reference microphone in the sound transmission loss rig for muffler testing.

The 42AG calibrator can be used for daily sensitivity calibration of the 46BD-FV ¼" CCP Pressure Standard Microphone Set with the included adapter.

### RECOMMENDED MICROPHONES AND CALIBRATORS

#### Sound Transmission Loss (Measurements on Test Rig)

<b>Test cell</b>	<b>46BD-FV</b>	¼" CCP Pressure Standard Microphone Set, Front Vented
<b>Calibration</b>	<b>42AG</b>	Multifunction Sound Calibrator, Class 1

#### Pass-by noise

The microphones for pass-by noise testing must fulfill the test procedures. Typically, a class 1, free-field microphone is used. Outdoor microphones with weather protection and internal heating are preferred for permanent installations.

The 146AE IP67-rated dust and waterproof microphone set is the ideal microphone for pass-by noise measurements. Even when temporary rain will stop your outdoor measurements, it is not necessary to disassemble your measurement setup, if using the 146AE microphone set. You can leave all equipment and quickly resume measuring when the rain stops.

The 146AE microphone set can be mounted with the AM0069 windscreen on the side of the test track using the AL0006 Microphone Tripod or the AL0004 Microphone Tripod in combination with the AL0008 ½" Microphone Holder. The AL0008 also requires the use of the AL0005 Swivel Head.

The 42AG calibrator can be used for daily sensitivity verification of the measurement microphones.

### RECOMMENDED MICROPHONES AND CALIBRATORS

#### Pass-by Noise

<b>Outdoor</b>	<b>146AE</b>	½" CCP Free-field Microphone Set
	<b>AL0004</b>	Small, Lightweight Microphone Tripod
	<b>AL0005</b>	Swivel Head
	<b>AL0006</b>	Microphone Tripod
	<b>AL0008</b>	½" Microphone Holder, POM
	<b>RA0093</b>	½" 5-click Microphone Holder, Stainless Steel
	<b>AM0069</b>	Spherical Windscreen for ½" Microphones
<b>Calibration</b>	<b>42AG</b>	Multifunction Sound Calibrator, Class 1



# GRAS Worldwide

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## About GRAS Sound & Vibration

GRAS is a worldwide leader in the sound and vibration industry. We develop and manufacture state-of-the-art measurement microphones to industries where acoustic measuring accuracy and repeatability is of utmost importance in R&D, QA and production. This includes applications and solutions for customers within the fields of aerospace, automotive, audiology, and consumer electronics. GRAS microphones are designed to live up to the high quality, durability and accuracy that our customers have come to expect and trust.

**GRAS** Sound & Vibration