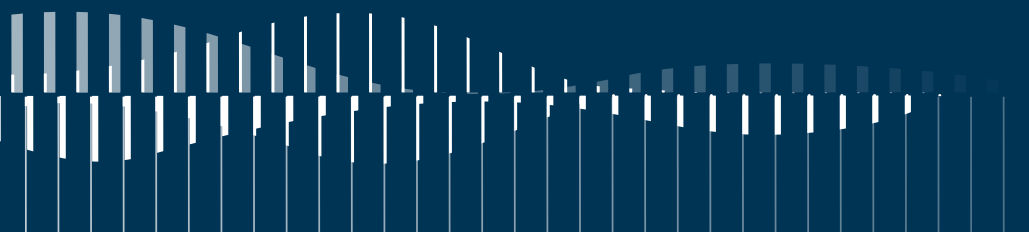


AUTOMOTIVE APPLICATION

Road Noise Testing



**ACOUSTIC
SENSORS
FOR PREMIUM
NVH DATA**



GRAS Sound
& Vibration

Road Noise Testing



Road noise is one of the most annoying interior noises in any vehicle and this problem is even more accentuated with more and more electrical vehicles on the market, leaving road noise, aero acoustic noise and, at certain conditions, heating, ventilation and air conditioning (HVAC) noise to be the dominating noise sources. External tire noise is also more and more critical for fulfilling pass-by noise regulations.

The road surface excitation is the source, and the cabin noise is both structure-borne and airborne. Frequencies below ~300 Hz are mostly structure-borne and above this frequency more airborne.

The noise is caused by the tire tread and road surface interaction. The tire tread design and tire sidewall stiffness have a lot of influence on cavity resonances that cause tonal noise around 200-250 Hz. The vehicle verification is done by analysis of sound pressure level (SPL), third octave band spectra, narrow band spectra and Articulation Index (AI) at different vehicle speeds and well-defined road surface types for noise, vibration and harshness (NVH) testing, e.g. smooth, coarse, grooved and standardized surface for pass-by noise measurements. Transient noise and comfort while driving over bumps must also be evaluated.

ACOUSTIC TEST TYPES WITHIN ROAD NOISE TESTING

Vehicle interior noise testing

A vehicle test on a NVH test track typically includes two to four microphones inside the vehicle distributed between the driver's and passenger seats. External microphones with high-performance windshield or intensity probes with nose cones can be used for measurement of tire near-field noise. Impact noise is measured on a dedicated test track with impact bars.

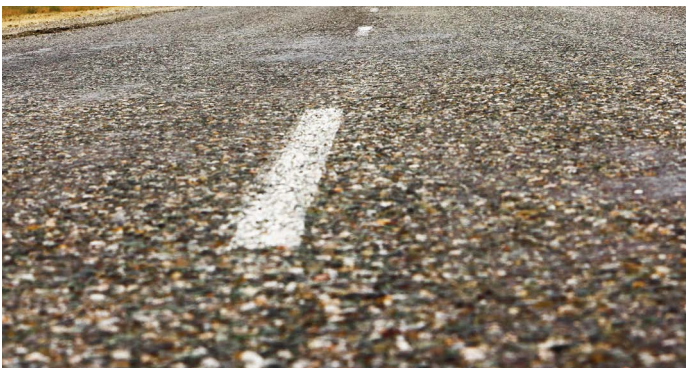
These tests together with sound power measurements can also be performed on a NVH chassis dynamometer equipped with road surface or impact bars during development. A test rig for the wheel only, adapted for the test track or the NVH chassis dynamometer, can be used for acoustic source measurements or pure tire development.

Structural testing is used for determination of the vehicle chassis sensitivity. Excitation is done with an impact hammer or shaker as well as a force transducer, and the acoustic response is measured with a measurement microphone at ear position. These tests in combination with vehicle tests and spindle force measurements will explain, if improvements are needed for vibration isolation to reduce low frequency road noise and/or tire cavity tonal noise.

Acoustic transfer function (ATF) testing

Acoustic transfer functions are measured between several positions in front of and behind the tire to understand the noise insulation from the wheelhouse to the cabin. This is done either with the direct method or reciprocally. The direct method involves using a calibrated omnidirectional sound source located at the tire, while the response is measured with one or more measurement microphones at ear position. For reciprocal measurements, the sound source is at ear position and the response is measured at the tire.

These measurements must be performed at several positions to include the source as well as the response. The result from such tests can show, if the acoustic pack needs improvement or, if there is a sound leakage. Pass-by noise is measured with dedicated microphones at a pass-by test track where all test equipment and facilities are thoroughly specified in the applicable standards.



CHALLENGES COMMON TO ROAD NOISE TESTING

Reliable equipment is critical since testing often is performed at a test track off-site. Rattle-free installation is extremely important to be able to evaluate high-frequency content that is not contributing to SPL, but to



sound quality. The measurement microphone field type is important since road noise is often analyzed above 5 kHz, and time data is sometimes also used for later playback for subjective noise comparison.

- Testing time should be short since the access to prototypes is limited.
- Microphone positioning should be done fast and easy, and in a way to record repeatable results.
- The microphones should be placed so that they minimize structure-borne sound.
- Microphone holders and cables should not introduce any rattling noise.
- The installation should be safe for the test engineer to perform during vehicle testing.
- Calibration verification should be easy to perform.

SELECTING THE RIGHT MICROPHONE

Vehicle interior noise testing

Microphones used for vehicle interior noise testing should have a frequency range up to at least 11,22 kHz to allow for the analysis to include the 10 kHz third octave band. Free-field or random-incidence ½" class 1 measurement microphones are used at ear position, and six or more microphones are used for far-field sound power measurements. The choice depends on the test procedures. Pressure or random-incidence microphones with low noise performance are recommended for acoustic transfer function (ATF) measurements where frequencies above 3-4 kHz are of importance.

When testing tire noise from the vehicle interior, the 146AE ½" CCP Free-field Microphone Set can also be used as a random-incidence microphone with the help of the RA0357 Random-incidence Corrector for 146AE. The 146AE is a robust microphone capable of withstanding dusty and humid environments and even shocks and drops.

The RA0504 GoPro Adaptor will help mount the 146AE or any other ½" measurement microphone on the wide variety of GoPro tripods, mounts and clamps available on the market. This will help make the microphone positioning inside the car quick and easy.

Far-field positioning of the 146AE can be done 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 42AG Multifunction Sound Calibrator can be used for daily sensitivity verification of the measurement microphones.

RECOMMENDED MICROPHONES AND CALIBRATORS		
Vehicle Interior Noise Testing		
In vehicle	146AE	½" CCP Free-field Microphone Set
	RA0357	Random-incidence Corrector for 146AE
	RA0504	GoPro Adapter
Far field	146AE	½" CCP Free-field Microphone Set
	AL0004	Small, Lightweight Microphone Tripod
	AL0005	Swivel Head
	AL0008	½" Microphone Holder, POM
	RA0093	½" 5-click Microphone Holder, Stainless Steel
Calibration	42AG	Multifunction Sound Calibrator, Class 1

Acoustic transfer function testing

For near-field measurements or troubleshooting of the tire, intensity probes and microphone arrays can be used and configured as per the analysis equipment needs. Measurements at the tire on road require nose cones or high-performance windshields. The possibility of easy verification of calibration will minimize test time and enable repeatable measurement results. The transducers are exposed to a lot of wear, often moved and even at worst case dropped to the floor. It is important to ensure that variation in environmental conditions do not influence the measurement performance.

The 147AX CCP Rugged Pressure Microphone will make ATF testing easy thanks to its small size and the possibility of mounting it even in the most difficult places and challenging environments (high and low temperature, high humidity, dust, etc.).

When space or mounting challenges are not a concern, the 146AE can be used with the RA0357 Random-incidence Corrector, if random-incidence response is needed for ATF testing. The 46BD ¼" CCP Standard Pressure Microphone Set or the 46AO ½" CCP Standard Pressure Microphone Set can be used, if pressure microphones are needed.

All the mentioned microphones can be calibrated using the 42AG calibrator and the included adapters.

RECOMMENDED MICROPHONES AND CALIBRATORS

Acoustic Transfer Function

Laboratory	46AO	½" CCP Standard Pressure Microphone Set
	46BD	¼" CCP Standard Pressure Microphone Set
	146AE	½" CCP Free-field Microphone Set
	147AX	CCP Rugged Pressure Microphone
	AL0008	½" Microphone Holder, POM
	RA0357	Random-incidence Corrector
	RA0504	GoPro Adapter
Calibration	42AG	Multifunction Sound Calibrator, Class 1

Troubleshooting

Array microphones like the 40PH and the 40PL CCP Free-field Array Microphones are cost-effective, free-field acoustic sensors designed to be mounted on large or small array modules like the PR0002 Module for Array Microphones for analysis of sound fields. These types of microphones are typically used in automotive testing for troubleshooting, measuring and locating sound sources using techniques like beamforming, near-field acoustic holography (NAH) and acoustic cameras.

A sound intensity probe like the 50GI-RP CCP Rugged Intensity Probe can also be used for sound source location, especially useful when testing in noisy environments and for areas difficult to access with microphone arrays. The 51AB Phase Calibrator according to IEC 61043 is used for level and phase calibration of the intensity probes.

Together the 147EB CCP X-Rugged Microphone Set and the 146AE is a perfect combination for on-road tire noise testing in challenging environmental conditions with microphones mounted outside and inside the car, respectively. For situations where high humidity, splashing of water and submersion into water prevail, we recommend adding watertight cables like the AA0103 10 m Waterproof BNC-BNC Cable.

All mentioned array and measurement microphones can be calibrated using the 42AG calibrator with the included adapters.

RECOMMENDED MICROPHONES AND CALIBRATORS

Troubleshooting

Laboratory	40PH	CCP Free-field Array Microphone
	40PL	CCP Free-field Array Microphone, High Pressure
	50GI-RP	CCP Rugged Intensity Probe
	PR0002	Module for Array Microphones, variable
On road	146AE	½" CCP Free-field Microphone Set
	147EB	CCP X-Rugged Microphone Set
	AA0103	10 m Waterproof BNC-BNC Cable (other lengths available)
Calibration	42AG	Multifunction Sound Calibrator, Class 1
	51AB	Phase Calibrator according to IEC 61043

GRAS Worldwide

Subsidiaries and distributors in more
than 40 countries

HEAD OFFICE, DENMARK
GRAS SOUND & VIBRATION
Skovlytoften 33
2840 Holte
Denmark
Tel: +45 4566 4046
www.grasacoustics.com
gras@grasacoustics.com

USA
GRAS SOUND & VIBRATION
5750 S.W. Arctic Drive
Beaverton, OR 97005
Tel: 503-627-0832
Toll Free: 800-231-7350
www.grasacoustics.com
sales-usa@grasacoustics.com

UK
GRAS SOUND & VIBRATION
Unit 115, Gibson House,
Ermine Business Park, Huntingdon,
Cambridgeshire, PE29 6XU
Tel: +44 (0) 7762 584 202
www.grasacoustics.com
sales-uk@grasacoustics.com

CHINA
GRAS SOUND & VIBRATION
Room 303, Building T6
Hongqiaohui, 990, Shenchang Road
Minhang District, Shanghai
China. 201106
Tel: +86 21 64203370
www.grasacoustics.cn
cnsales@grasacoustics.com



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.

grasacoustics.com

GRAS Sound
& Vibration