Detection of Reflecting Objects in Anechoic Chambers

Abhay Rajmane[1], Walter Baumann[2]

[1] *G+H Schallschutz GmbH, 67059 Ludwigshafen, E-Mail: abhay.rajmane@guh-gruppe.de*

[2] *G+H Schallschutz GmbH, 67059 Ludwigshafen, E-Mail: walter.baumann@guh-gruppe.de*

Introduction

Ideally anechoic chambers are supposed to absorb more than 99% sound energy. But unavoidable objects like power sockets, camera, siren, fire extinguisher, illumination devices, ventilation flaps, smoke detector, digital display etc. reflect the incident sound.

In the first part of this work correlation is established between the size of reflecting object and the tonal frequency of excitation from the experiments in an anechoic chamber. In the second part of this work, the distance of reflecting object relative to sound source and microphone is estimated.

The outcome of this research work is one measurement procedure that identifies the size and location of the reflecting object. It guides to relocate or reorient the reflecting object, so that the region of acoustic interest in anechoic chambers remains clean and without reflections.

Anechoic Chambers Qualification Procedere

The qualification procedure of anechoic chambers is defined in DIN EN ISO 3745 Annex A and in ISO 26101. The procedure can be explained with help of diagram 1. The spherical point sound source is located at usual test specimen location (preferable center). The sound pressure level is measured along the radial outward path from sound source to the acoustic absorption cladding. The sound pressure must decrease according to inverse square law of distance between microphone and sound source. Any deviation indicates the incomplete absorption or reflection of sound in anechoic chamber.

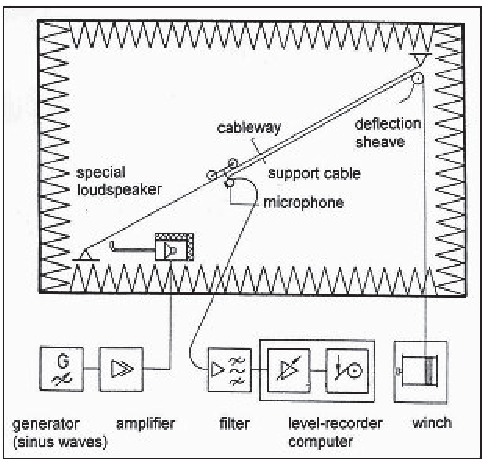
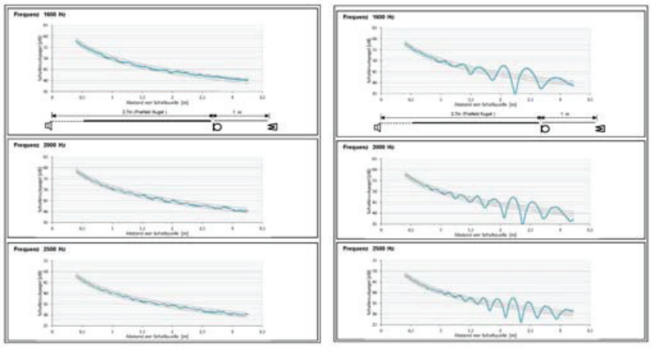


Diagram 1: Qualification Procedure of Anechoic Chamber

The diagram 2(a) shows the fall of sound pressure level in ideal anechoic chamber without any reflections. When a reflecting area is present in anechoic chamber, the constructive and destructive interferences of sound wave are generated as observed in diagram 2(b). The zone of these interferences cannot be qualified as free-field region for given source location and given (reflecting) objects inside anechoic chamber.



(a) (b)

Diagram 2: Graph of sound pressure level vs distance between sound source and measuring microphone at three different tonal excitation frequencies, (a): without reflecting element and (b): with reflecting element

Part 1: Identifying Size of Reflecting Objects

Initially the fully anechoic chamber without reflectors is measured along a specific path. Then reflectors of known sizes are mounted on tripod at specific location in anechoic chamber and the sound pressure level is measured along path. The measurement path and centerline of reflector is placed at 1.5m height above the walking net. The diagram 3 shows the measurement path and typical location of reflector in this series of measurements.

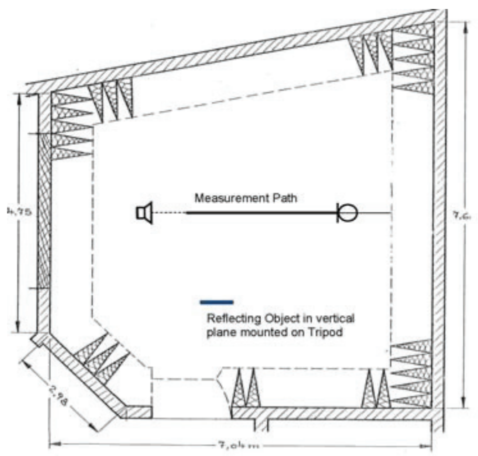


Diagram 3: Typical source- and reflector location, as well as measurement path for establishing correlation between size of reflector and tonal frequency of excitation.

A 1.5mm thick steel sheet in different sizes is used as reflector. The room is excited with tonal sound by one-third octave band center-frequency and microphone is moved along the specified path. Table 1 shows the excitation frequencies and occurrence of visible interference with reference to tolerances given in Annex A of DIN EN ISO 3745.

Tabel 1: Occurrence of interference in relation to tonal excitation frequency and size of reflecting object

Frequency [Hz]	Wavelength [cm]	Square Reflector LxW = 35 x 35cm	Square Reflector LxW = 10 x 10cm
800	42.5	No	No
1000	34.0	**Yes**	No
1250	27.2	Yes	No
1600	21.3	Yes	No
2000	17.0	Yes	No
2500	13.6	Yes	No
3150	10.8	Yes	**Yes**
4000	8.50	Yes	Yes
5000	6.80	Yes	Yes

Yes: Interference observed, No: Interference not observed

In order to study effect of shape of reflecting object, another rectangular reflector of size 70 x 17 cm is selected keeping the surface area same as that of 35x35cm reflector. This rectangular reflector is placed in two different orientations relative to measurement path. Table 2 shows the excitation frequencies and occurrence of visible interference with reference to tolerances given in Annex A of DIN EN ISO 3745.

Table 2: Occurrence of interference in relation to tonal excitation frequency and size of reflecting object

Frequency [Hz]	Wavelength [cm]	Rectangular Reflector L x W = 17 x 70cm	Rectangular Reflector L x W = 70 x 17cm
800	42.5	No	No
1000	34.0	**Yes**	**Yes**
1250	27.2	Yes	Yes
1600	21.3	Yes	Yes
2000	17.0	Yes	Yes
2500	13.6	Yes	Yes
3150	10.8	Yes	Yes
4000	8.5	Yes	Yes
5000	6.8	Yes	Yes

Yes: Interference observed, No: Interference not observed

Observations from table 1 and 2 show that reflecting object is identified, when length of side of square object is greater than or equal to wavelength of tonal excitation frequency. For the rectangle shaped reflector with L:W up-to 4:1, the object is still identified, when length of side of equivalent square object is greater than or equal to wavelength of tonal excitation frequency.

Part 2: Identifying Location of Reflecting Object

To identify the relative location of reflecting object, the microphone is placed at location along the measurement path, where constructive interference is observed (refer to diagram 4). The source is excited with Sine Burst Wave for the half period of excitation frequency. The sound signal at microphone is analyzed in time domain at very short interval, as small as 60 µsec. The time difference between direct wave from loudspeaker and indirect wave from reflecting object is measured.

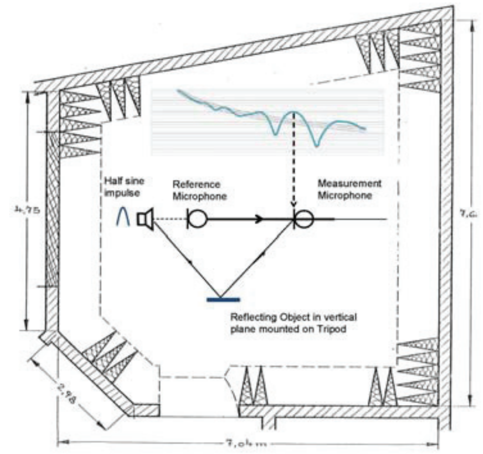


Diagram 4: Typical source- and reflector location, as well as measurement path for measuring location of reflecting object

The difference between direct path and reflected path is calculated from velocity of sound and measured time lag. Table 3 shows the results of three tests with different reflector locations.

Table 3: Measured time lag and distance for three different reflector positions

Measured time lag between first and second impulse	Calculated path difference from time lag	Measured path difference
3.5 ms	1.2 m	1.2 m
2.3 ms	0.8 m	0.7 m
12 ms	4.1 m	4 m

Suppose we identify standing waves in the measurement path shown in diagram 5. There are three possible reflecting objects as ventilation flaps, power socket and digital display on three walls. After measuring time lag and estimating distance of reflected object, the distances of three objects can be measured from sound source and microphone. Thus the exact reflecting object can be identified.

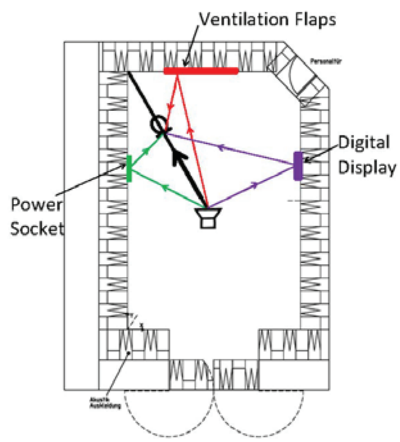


Diagram 5: Typical source- and reflector location, as well as measurement path and reflecting paths in automobile test bench

Summery

If deviations from inverse square law are observed during anechoic chamber qualification measurement according to ISO 26101, the information about reflecting object can be judged. The approximate size of reflecting object is equal to wavelength of lowest tonal sound wave, at which the reflecting object is identified. The distance of reflecting object from sound source can be identified by emitting sine impulse and measuring the time lag of reflected sound on the measurement path. From this information, if any object is disturbing the free field acoustic region, the object can be shifted to different safe location.

References

[1] DIN EN ISO 3745:2012-07, Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for anechoic rooms and hemi-anechoic rooms

[2] ISO 26101, Acoustics – Test methods for the qualification of free-field environments