ICS 17.140.01
CCS A59

NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/Z 27764-2011

Acoustics - Determination of sound transmission loss in impedance tubes - Transfer matrix method

声学 阻抗管中传声损失的测量 传递矩阵法

Issued on: December 30, 2011 **Implemented on: December 30, 2011**

**Issued by: State Administration for Market Regulation;
Standardization Administration of China**

Table of Contents

1 Scope

This guiding technical document specifies the measurement, by the transfer matrix method, of the normal incidence sound insulation (also called the normal incidence sound transmission loss) of acoustic materials or acoustic structures in an impedance tube. This guiding technical document applies to the measurement of the normal incidence sound insulation of locally reacting acoustic materials such as foam, cotton felt and soft thin plates whose test frequency lies in the mass-controlled region, that is, materials inside which there is no sound propagation parallel to their surface; it applies to the comparison of the sound insulation performance of acoustic materials at the development stage. Because the sound transmission loss of a material is closely related to its physical properties, such as elastic modulus, density and structure factor, the measuring method specified in this guiding technical document can be applied to the related basic research and product development. This guiding technical document does not apply to the qualification testing of the sound insulation performance of a product. This guiding technical document uses an impedance tube, one or more microphones and a digital acquisition and analysis system.

This guiding technical document stipulates the measurement of normal incidence sound insulation (or normal incidence sound transmission loss) of acoustic materials or acoustic structures, in impedance tubes, by using the transfer matrix method. This guiding technical document is applicable to the measurement of the normal incidence sound insulation of locally reactive acoustic materials, such as sponges, cotton felts, soft thin plates, whose test frequency is in the quality control area (that is, there is no sound propagation parallel to the material inside the material). It is applicable to the comparison of sound insulation performance of acoustic materials, in the development stage. Since the sound transmission loss of a material is closely related to its physical properties (such as elastic modulus, density, structure factor, etc.), the measurement methods specified in this guiding technical document can be applied to relevant basic research and product development. This guiding technical document is not applicable to the identification test of the sound insulation performance of the product. This guiding technical document uses an impedance tube, one or more microphones, and a digital acquisition & analysis system.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

GB/T 3947-1996 Acoustical terminology

GB/T 18696.2-2002 Acoustics - Determination of sound absorption coefficient and impedance in impedance tubes - Part 2: Transfer function method

3 Terms and definitions

The following terms and definitions apply to this document.

3.1 Normal incidence [sound] pressure transmission coefficient taup The ratio -- of the sound pressure transmitted through a material or structure TO the incident sound pressure, when the sound wave is incident on the normal direction.

Note: Rewrite GB/T 3947-1996, Terms and Definitions 12.37.

3.2 Normal incidence [sound] transmission loss TL The difference -- between the incident sound power level on one side of the material and the transmitted sound power level on the other side -- when the sound wave is incident on the normal direction. The sound transmission loss is equal to the reciprocal of the square of the sound pressure transmission coefficient, taking the logarithm to the base 10, in the unit of Bell [B]. However, it is usually measured in decibels (dB).

Note: Rewrite GB/T 3947-1996, Terms and Definitions 12.26.

3.3 The first reference plane The cross-section of the impedance tube, which is used to measure the sound pressure transmission coefficient. If the surface of the test piece is flat, usually take the front surface of the sample as the first reference plane.

Note: Rewrite GB/T 18696.2-2002, Terms and Definitions 3.3.

3.4 The second reference plane The cross-section of the impedance tube, which is used to measure the sound pressure transmission coefficient. If the surface of the test piece is flat and the thickness of the sample is t, the second reference plane is usually taken at x = t.

Note: Rewrite GB/T 18696.2-2002, Terms and Definitions 3.3.

3.5 Wave number in the air sequence noise or chirp. Measure the sound pressure, at two positions close to the sample in the front tube, to obtain the sound pressure transfer function of the two microphone signals. Similarly, measure the sound pressure, at two positions close to the sample in the back tube, to obtain the sound pressure transfer function of the two microphone signals. Calculate the normal incident transmission coefficient of the test piece (see Appendix B), sound transmission loss, other related acoustic quantities, by the transfer matrix method. These quantities are all functions of frequency. Frequency resolution depends on the sampling frequency and the measurement record length of the digital acquisition and analysis system. The effective frequency range is related to the lateral dimension or diameter of the impedance tube, as well as the spacing between the two microphones. With different sizes or combinations of diameter and spacing, a wide range of measuring frequencies can be obtained. Measurements can be made in one of two ways:

a) Four-microphone method (measured by four microphones at a fixed position);

b) Single-microphone method (measured by one microphone at four positions in sequence).

5 Test equipment

5.1 Structure of impedance tube The impedance tube is divided into front tube, back tube, test piece holding tube. One end of the front tube is connected to the sound source, the other end is connected to the test piece holding tube. One end of the rear tube is connected to the test piece holding tube, the other end is a closed end with certain sound absorption performance. There are four microphone mounting holes, two for the front tube and two for the rear tube, arranged along the tube wall. The impedance tube shall be straight; its cross-sectional area shall be uniform (the deviation of diameter or cross-sectional size is within ±0.2%); the wall of the tube shall be smooth, rigid, dense enough, so that it will not be excited by the acoustic signal. There is no resonance in the working frequency band of the impedance tube. For round metal tubes, it is recommended that the wall thickness be taken as about 5% of the tube diameter. For rectangular tubes, the four corners must have sufficient rigidity, to prevent deformation of the side plates. It is recommended that the plate thickness be taken as 10% of the cross-sectional size of the impedance tube. The tube wall, which is made of cement, can be painted with a well-mixed adhesive, to ensure airtightness. The same measures shall be taken for tube walls, which are made of wood. Cement tube walls and wooden tube walls shall also be covered with iron or lead, to increase strength and damping. if the requirements of formula (4) are met, the distance between the microphones shall be greater than 5% of the corresponding wavelength of the test low frequency. Increasing the distance between the microphones can improve the measurement accuracy. If it wants to expand the test frequency band, it can use a combination of microphones with different spacing to achieve it. Note that there needs to be a frequency overlap, at the connection of each frequency band.

5.3 Impedance tube length The impedance tube shall be long enough, to generate a plane wave between the sound source and the test piece. In addition to plane waves, loudspeakers generally produce non-plane wave modes. For those non-plane wave modes, which have frequencies below the cutoff frequency, they will attenuate within a distance of about three tube diameters (for round tubes) or three times the length of the long side (for rectangular tubes). Therefore, it is recommended that the distance between the microphone and the sound source shall not be closer than the above-mentioned distance. In any case, it is better not to be less than one tube diameter or one long side length. Test pieces can also cause distortion of the sound field. According to the type of sample, the recommended minimum distance between the microphone and the sample is: Flat surface of uniform material: 1/2 of the diameter of the tube or 1/2 of the length of the long side; Flat surface of non-uniform structure: 1 times the tube diameter or 1 times the length of the long side; Asymmetrical or rough surfaces: 2 times the tube diameter or 2 times the length of the long side.

5.4 Test piece holding tube The test piece holding tube can be independent and detachable, OR it can be integrated with the front tube and the rear tube, OR it can be composed of inner and outer tubes.

5.4.1 Integral test piece holding tube For the impedance tube made as a whole, it is recommended to make the upper part of the tube, where the test piece is placed, as a movable cover. The contact surface between the movable cover and the holding tube shall be carefully ground; it is recommended to use a sealant (grease) to avoid leaks.

5.4.2 Detachable test piece holding tube center of the microphone, see A.2.

5.9 Signal processing equipment The signal processing equipment consists of a signal generator, a power amplifier, and a four-channel fast Fourier transform (FFT) analyzer. The device measures the sound pressure at four microphone positions; calculates the Fourier spectrum or transfer function, at each location. The signal generator shall be capable of generating a source signal suitable for the analyzer (see 5.11). Analyzer's dynamic range shall be greater than 65 dB. The estimation error of the transfer function, due to the nonlinearity, resolution, instability, temperature sensitivity of the signal processing equipment, shall be less than

0.2 dB. When the single-microphone method is used, the analyzer shall be able to calculate the transfer function Hij, from the generator signal and two successively measured microphone signals.

5.10 Loudspeakers The diaphragm loudspeaker (or the high-frequency pressure-cavity type loudspeaker with the horn as the transmission unit of the impedance tube) shall be placed, at the end of the front tube, as opposite to the test piece holding tube. The loudspeaker's