THE WAY AUDIO TESTS

Part 3: Speakers

To accurately measure loudspeakers, the in-house Testlab that works for AUDIO has invested more than EUR 150,000 in an anechoic chamber and the related equipment. - Read how we use this equipment to analyse loudspeakers. ■ By Bernd Theiss

For the pros: The term ‚anechoic' is often used in colloquial speech, whereas scientists and engineers speak of a ‚semi-anechoic chamber'. The special construction used by Testlab is semi anechoic, with a ground surface reflecting sound waves almost one hundred percent – more on this later.

Side walls and ceiling of the chamber – with a floor area of approximately 5 x 5.5 meter and 3 meters height – are lined with wedge absorbers for medium and high frequencies, behind which variable panel absorbers have been installed for the low frequencies. Overall, the combined system developed by the Illbruck specialists has a thickness of 720 millimetres. The measuring chamber must not only be protected inside against distorting reflections, it also had to be shielded against disturbing noise from the outside by means of special sound proofing wall constructions.

But even the most effective absorbers cannot prevent the influence of the chamber on very low frequencies. The booming, standing waves that HiFi enthusiasts are familiar with are indeed much less pronounced than in living rooms, but can still negatively affect the measurement accuracy. To exclude these effects, Testlab has developed a sophisticated three-step measuring procedure for the determination of said amplitude frequency response, colloquially known as frequency response.

(AMPLITUDE) FREQUENCY RESPONSE

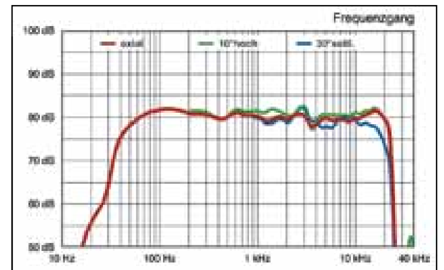
In the first measurement, the frequency response between 300 Hz and 40 kHz is measured in the so-called free-field. For this purpose, the loudspeaker is placed on a reference platform and moved for the measurement to the predetermined location with the acoustic centre between midrange and tweeter at a height of 1.53 meters. Three Brüel & Kjaer 4191 microphones specialized for free-field measurements (frontal incidence waves) are oriented so that they measure the frequency response at the standard distance of one meter directly on the axis, once at a 10-degree upward angle and at 30 degrees to the side.

An on-axis free-field measurement is the ultimate standard for many developers because it reflects the frequency response of the direct sound from speaker to ear. From this, the listener can gain a first impression on the sound (dis)colouration of an acoustic event. However, our perception of tonality is also influenced by individual reflections and reverberation effects composed of multiple reflections. Otherwise we could not distinguish between muffled spaces with highly muted high frequency range and bright, highly reflective spaces. We would also not be affected by booming, standing waves.

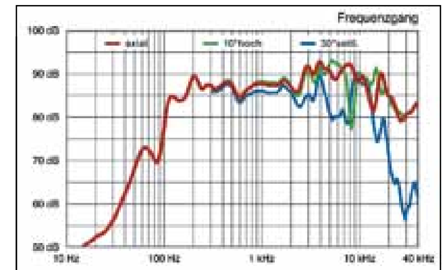
We speak about a free-field measurement when only the part of the measurement coming directly from the speaker flows into the result. All reflections that arrive later due to the longer distances are masked out by the measuring system. This so-called windowing however limits the measuring time and accuracy at low frequencies, as these have longer periods. You have to measure at least one full cycle in order to determine its amplitude: Those looking to capture low frequencies in short measurement times, are sure to botch it.

Testlab therefore uses the so-called ground-plane measurement for the 90 to 300 Hz range. In this measurement, speaker and microphone lie on the floor. Since the latter almost completely reflects the sound, it acts like a mirror. It is as if two loudspeakers were measured simultaneously in double the space – with a correspondingly longer anechoic measurement time. The ground-plane measurement delivers accurate results in the chamber up to 90 Hz. Underneath this threshold, the influence of the room becomes noticeable again, which is why the so-called near-field measurement is deployed. For this purpose, each driver wor-

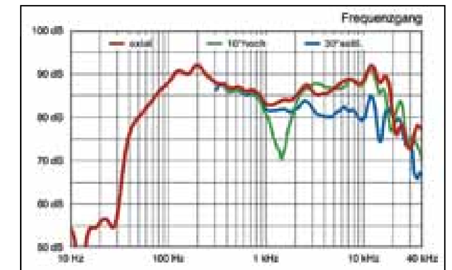
ONLY THE BEST: the microphone capsules B&K 4191 operate completely linearly from 3 hertz to 40 kilohertz, and from 20 to 162 dB (re 20 µPa).



GOOD FIT: the amplitude frequency response shows how well-balanced this speaker outputs all frequencies, from the low 40 Hz to extremely high, beyond 20 kilohertz.

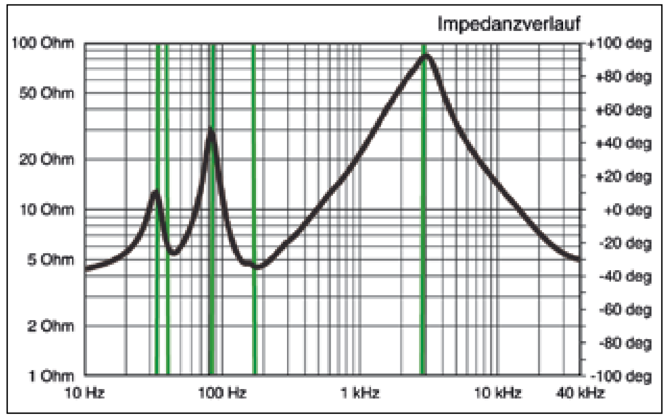


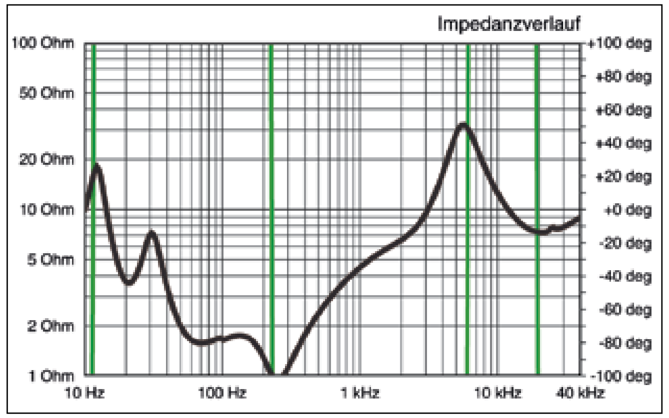
NO BASS: this loudspeaker does not use bass, as seen at the rapid drop below 100 Hz. It emphasizes the high-frequency range especially on the axis (red), while dropping below 30 degrees (blue)



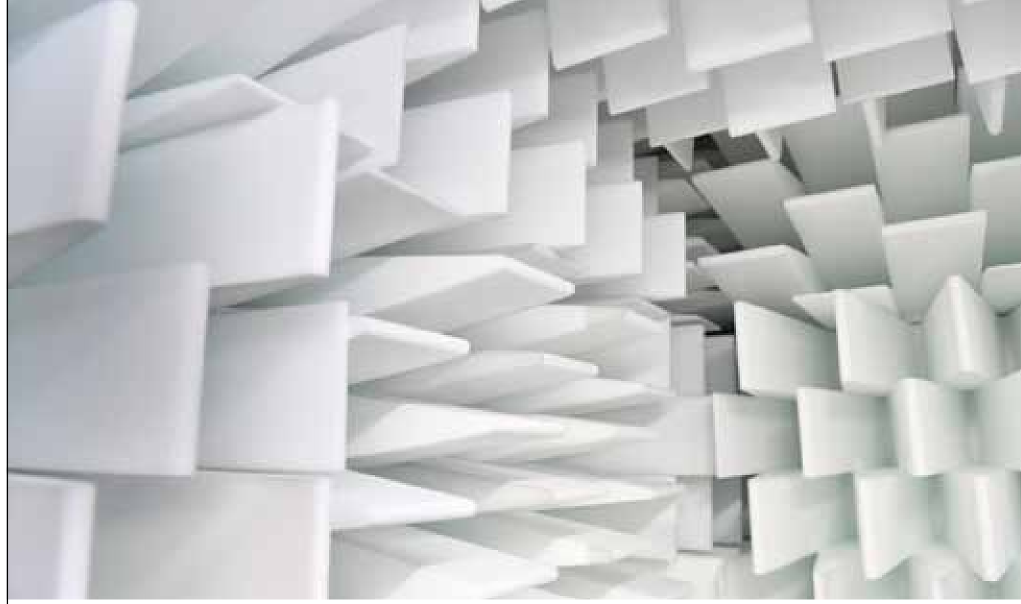
PLEASANT: the tub-shaped frequency response from 100 Hz to 10 kHz is perceived as particularly pleasant. After long listening, however, the experience can be tainted by discolouration and early bandwidth limitation.

EXPENSIVE: Measurement technology stands in front of the semi anechoic chamber.

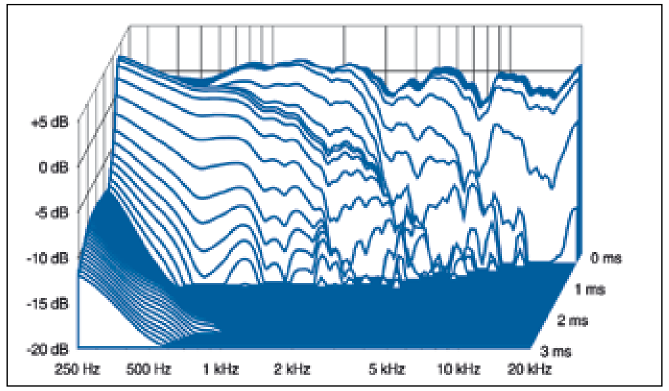


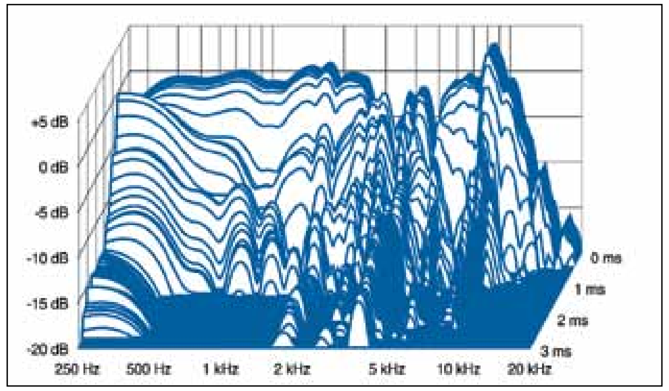


IMPEDANCE: The impedance frequency response provides information on how a loudspeaker loads the amplifier at different frequencies. Minimum fluctuations are advantageous for all amplifiers. Dips under 2 or even 1 ohm, as shown in the right measurement diagram, can damage the amplifier. From the sound pressure measured at a defined input voltage and impedance, the Testlab measurement software automatically calculates the AUDIO classification number for amplifier matching..

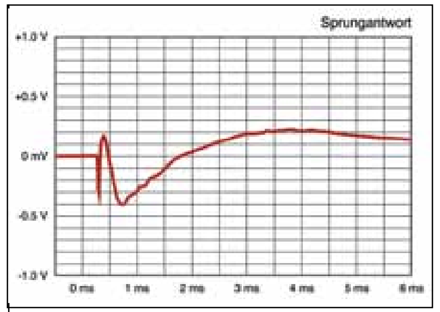


SOAKED: Absorber attenuate sound waves hitting the walls of the measurment chamber.

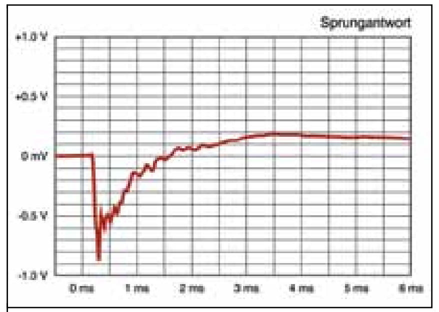




WATERFALL CHART:
the waterfall chart shows how quickly an excited speaker comes to rest again. The rear curve (at 0 ms) corresponds to the frequency response. The curves in front of this show how much energy it radiates after up to 3 milliseconds. On the left a very good speaker is shown, on the right a speaker with particularly strong resonances between 1.8 and 5 kilohertz.

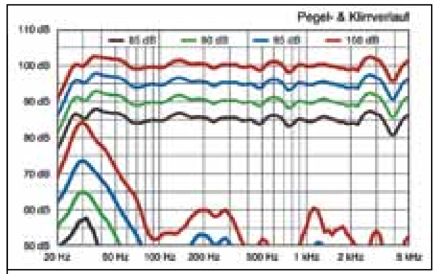


TIME SPAN: the step response of a typical multi-way speaker changes polarity during the measurement several times.

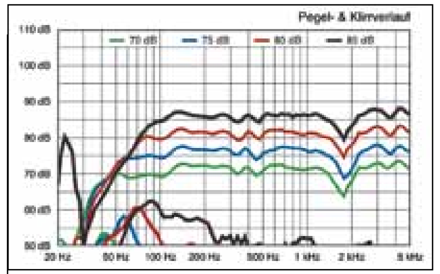


A STEP BETTER: in a full-range speaker the step response comes without a change of polarity.

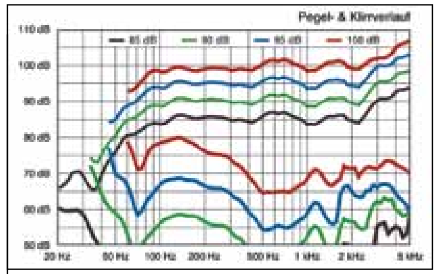
king below 90 Hz and any bass reflex port, transmission-line or horn mouth are measured individually in close proximity. The distance here is about one centimetre. The overall sound pressure can be calculated based on the geometric contribution of the individual sound-radiating surfaces. In near-field measurements, the surrounding space plays virtually no role because the speaker is much louder than reflected waves, which have to travel a very long distance compared to the 1 centimeter between sound source and microphone. The software developed to Testlab specifications, the outrageously expensive Audio Precision System 2 and microphones, including self-developed 8-channel preamplifier, ensure all measurements are easily linked to a frequency response. The microphone equipment alone came with a price tag of 22 000 euros. It's worth the price, as it greatly expands the capabilities of the Testlab measuring system.



MASTER CLASS: with the exception of the bass, this speaker shows significant distortions (red, below) only at 100 dB output (red, upper curve).



REALLY SMART: to prevent distortion caused by over-excursion of the bass drive, this active speaker system cuts down the bass at high volumes.



AT THE LIMIT: his speaker-system produces broadband distortions pretty early, as shown in the lower curve at 90 dB (green), 95 dB (blue) and 100 dB.

Another ground-plane measurement allows us to determine maximum level and distortion in the range of 20 Hz to 5 kHz. At low frequencies, speakers must move a lot of air, which makes them prone to distortion. In the sound level and distortion curve test, frequency response and THD are jointly measured at the mean levels of 85, 90, 95 and 100 dB and marked with different colors. The distortion curves associated with the levels ideally should be below the visible area of the diagram. Only at low frequencies the ears sensitivity to extremely low distortions decreases. What's more, the distance of the individual frequency sweeps should be exactly 5 dB, as otherwise speaker compression will eliminate differences in the dynamic range. Some small active speakers do so deliberately in the low frequencies, to tackle distortions caused by long cone excursion. But passive boxes also compress, e.g. when voice coils heated by high levels increase their impedance (AC resistance) and thus take on less power. Testlab also measures the maximum sound pressure which speakers can deliver confidently. To do this, the level increases steadily until the speaker exceeds the distortion limit of 1% in the mid-range, or compresses the sound pressure increase by 3 dB. Higher distortion is allowed at low frequencies (250 Hz: 4%, 100 Hz: 10%) because the ear is less sensitive to distortion here.

In addition to frequency response and distortion, Testlab also uses a waterfall plot to capture how long it takes an stimulated loudspeaker to come to a rest. Another very important measurement is the impedance response. This shows how strongly a passive speaker loads the amplifier. Strong fluctuations can unsettle bad transistor amplifiers while a low minimum impedance, in contrast, can be harmful for tube amps.

CONCLUSION

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Tests can identify strengths and weaknesses, especially in loudspeakers. To ensure neutrality, a straight and angle-independent frequency response is necessary. For the necessary authority, it should not shun the lowest bass notes and extend far beyond 10 kHz for lucid high frequencies. For those who revel in high volumes, a look at the level and distortion curves is also a must. Negligible Distortion in the midrange and low compression are a prerequisite for basking in high sound levels, while providing an almost tangible airiness in the bass.