GRAS Sound & Vibration
An Axiometrix Solutions Brand

What are the free-field and random incidence corrections? How should I use them?

Free-field and Random incidence (also known as diffuse-field) corrections are available for most GRAS measurement microphones. These values are showing how a specific microphone disturbs the sound field due to the diffraction effect.

Free-field and Random incidence corrections for most GRAS microphones can be found here in our website.

In order to obtain the free-field corrections of a microphone, the microphone under test is placed in a free-field environment and exposed to a well-known reference signal (like a logarithmic sine sweep). The microphone is first pointed at 0-degree incidence from a reference sound source with well-known frequency response. The frequency range for the test will depend on the frequency range of the microphone and its size. For example, a GRAS 46BE ¼" free-field microphone set has a frequency range from 4 Hz to 80 kHz, but will cause a sound pressure increase (due to diffraction effect) of less than 0.09 dB below 2kHz and no disturbance at all below 500 Hz. Once the results for 0-degree incidence are obtained, the microphone or sound source can be rotated to obtain results for different angles. As in reality there is no sound source that has a complete flat frequency response, we will need to compensate for the uneven response. We are interested in measuring the disturbances in the field caused by the microphone only and not the frequency response of our sound source. In order to differentiate which deviations are caused by the influence of the microphone in the sound field and which are caused by the bumpy response of our sound source, we will have to repeat the same measurement procedure we just did, but with a smaller microphone. A smaller microphone will movethe diffraction effect to higher frequencies and therefore will allow us to precisely assess the frequency response of the sound source so we can compensate for its unevenness.

The procedure described above can be replicated in a diffuse-field environment (like a reverberant chamber) to obtain the random incidence corrections of a measurement microphone.

The free-field and random incidence corrections are typically used for two specific purposes:

1) Due to its convenience and ease of implementation, the electrostatic actuator method is one of the most common methods used to obtain the pressure frequency response of a measurement microphone. When calibrating a free-field or random incidence microphone, the pressure frequency response will be measured first and then its free-field/diffuse-field response will be calculated by adding the free-field/random-incidence corrections to the pressure response (See Figures 1, 2 and 3):

Calculated Free-field response = Measured Pressure response + Free-Field correction

Calculated Random incidence response = Measured Pressure response + Random incidence correction

Example:
Let´s say I´m calibrating a GRAS 40AE ½" free-field microphone capsule and I measure a pressure response -0.40 dB @ 2 kHz (referred to 250Hz). If the free-field correction @ 2 kHz and 0-degree incidence for that microphone is 0.46 dB, then I can calculate the free-field response as follows:
Calculated Free-Field response (@2kHz, 0-deg) = -0,40 dB + 0.46 dB = 0.06 dB (referred to 250 Hz).

Then the corrected response in the entire frequency range can also be calculated.

Type :	40AE		Result:	Free field corrections				
dB relative to response at 250 Hz				with protection grid				
	0°	30°	60°	90°	120°	150°	180°	Random
500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
560	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
630	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00
710	0.05	0.06	0.02	0.00	0.00	0.00	0.00	0.00
800	0.08	0.07	0.04	0.00	0.00	0.00	0.00	0.00
900								
1000								
1120								
1250								
1400								
1600								
1800								
2000								
2240								
2500								
2800								
3150								
3550								
4000								
4500								
5000								
5600								
6300								
7100								
8000								
9000								
10000	4.63	3.88	2.59	1.01	-0.36	0.00	0.74	1.61
11200	5.53	4.72	3.08	1.03	-0.57	-0.06	0.72	1.95
12500	6.42	5.43	3.53	0.91	-0.99	-0.61	0.23	2.20
14000	7.22	6.21	3.88	0.95	-1.56	-1.28	-0.32	2.45
16000	8.02	6.90	4.10	0.72	-2.20	-1.95	-0.67	2.64
18000	8.59	7.36	4.10	0.06	-3.04	-2.84	-2.22	2.68
20000	9.05	7.43	3.88	-0.83	-4.24	-3.99	-3.50	2.47

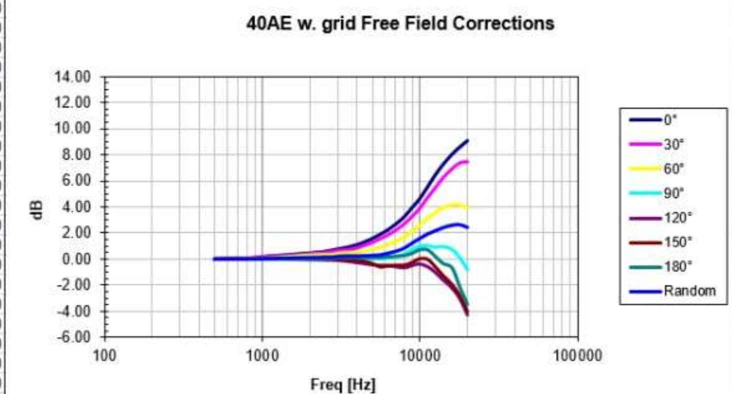

Figure 1. Typical Free-field corrections chart for a GRAS measurement microphone at different angles of incidence. Random incidence correction is also shown.

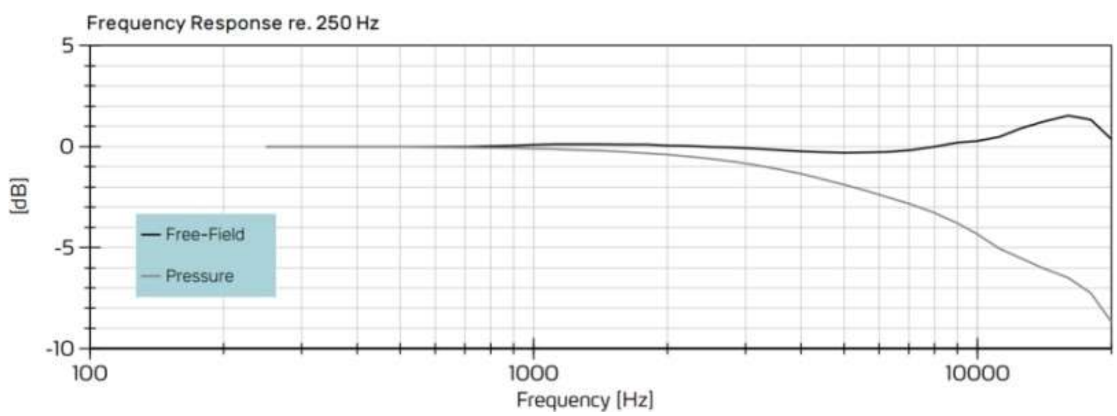

Figure 2. Measured pressure response and calculated free-field response of a free-field measurement microphone.

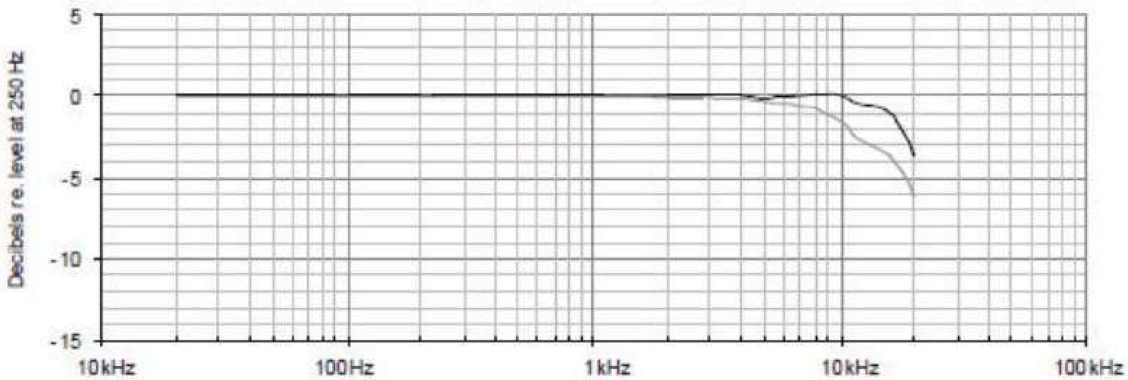

Figure 3. Typical frequency response of a random incidence microphone. Upper curve shows calculated response in a diffuse sound field (random incidence), lower curve shows measured pressure response.

2) When a pressure microphone is used in a free-field/diffuse-field environment, the diffraction effect will cause a pressure build up that will be measured by the microphone. If we have free-field/random-incidence corrections for that pressure microphone, then it will be possible to process the measured data to get rid of the pressured build up caused by the diffraction effect. This way, the postprocessed data will be the same as if the measurement was made with a free-field/random-incidence microphone:

Corrected response = Measured data with pressure microphone in a free-field environment – Freefield corrections

Corrected response = Measured data with pressure microphone in a diffuse-field environment - Random incidence corrections

Example:
I´m using a GRAS 46A0 ½" pressure microphone set in a free-field environment pointing at 60-degree incidence from my sound source. I´m measuring 75 dB @ 10 kHz. Free-field corrections from 46AO provided by GRAS shows that @ 10 kHz and 60-degree incidence the correction is 2.09 dB.
Then I can calculate the corrected response as follows: Corrected response (@ 10 kHz, 60-degree incidence) = 75 dB – 2.09 dB = 72.91 dB.

Then the corrected response in the entire frequency range can also be calculated.