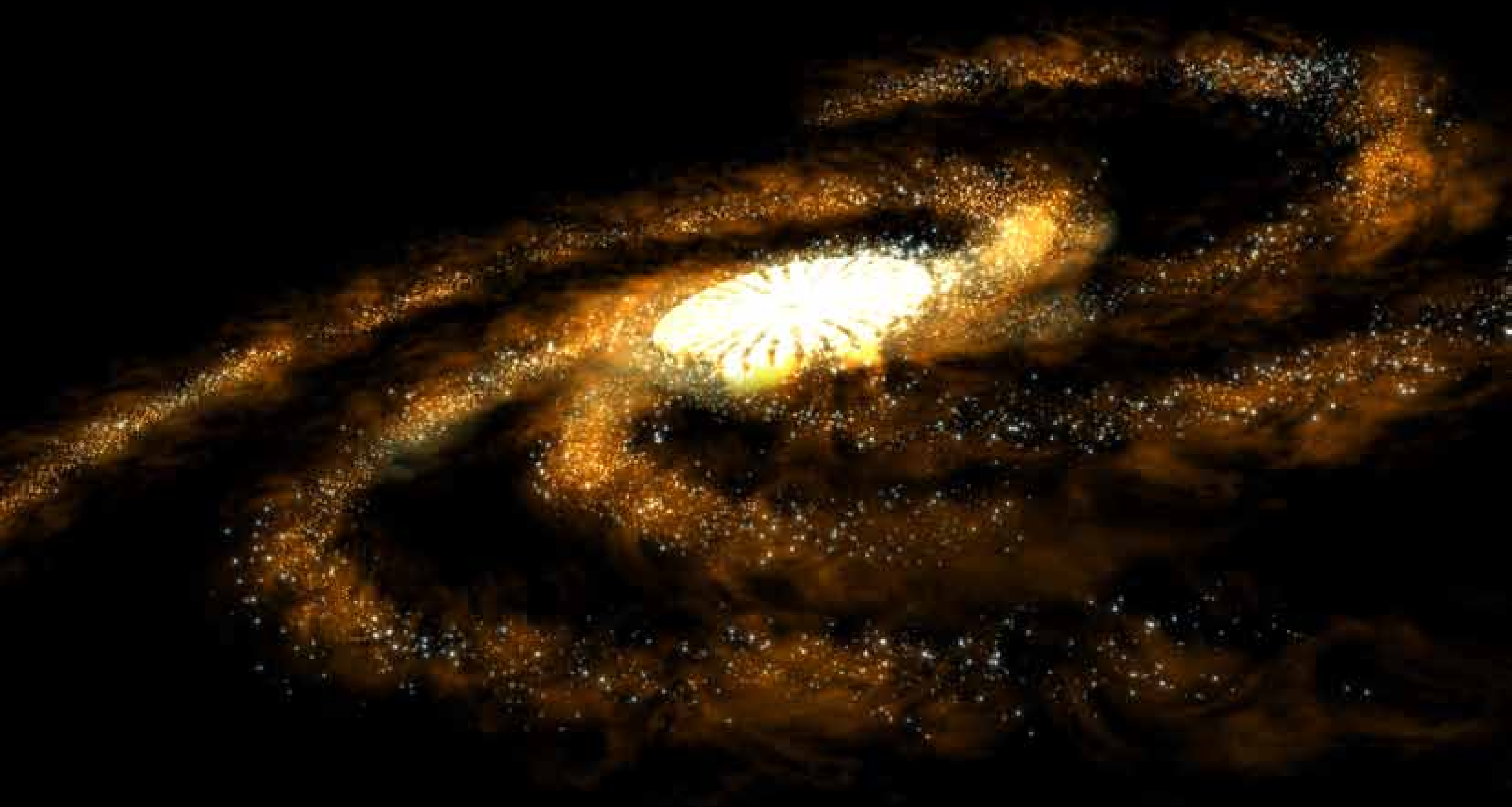
How to choose the right mic for the job

The essentials

of microphone technology



DPA MICROPHONES

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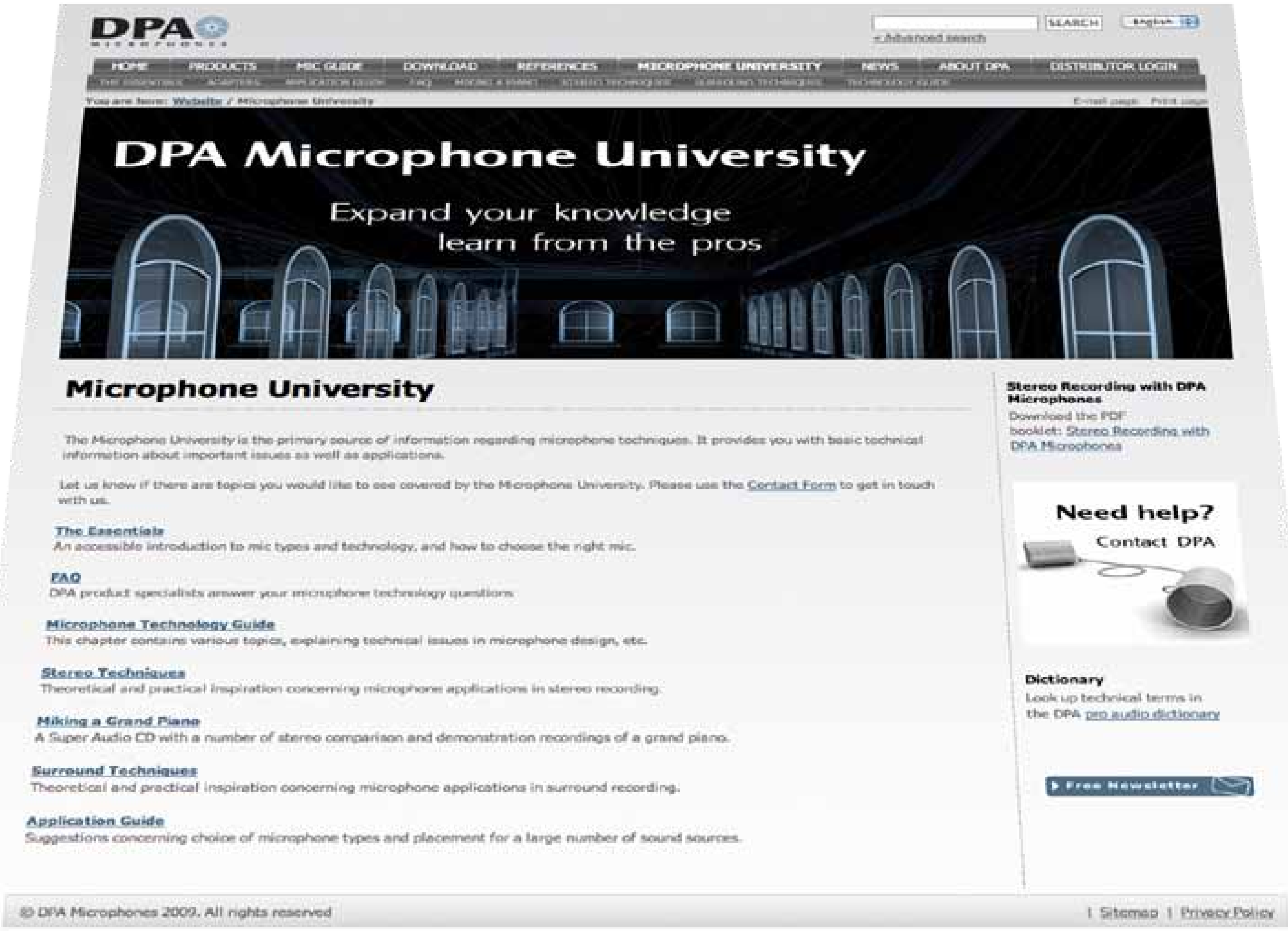
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An accessible introduction to mic types and technology, and how to choose the right mic.
FAQ
DPA product specialists answer your microphone technology questions.
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This chapter contains various topics, explaining technical issues in microphone design, etc.
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Theoretical and practical inspiration concerning microphone applications in stereo recording.
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A Super Audio CD with a number of stereo comparison and demonstration recordings of a grand piano.
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Application Guide
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Getting the right microphone

Before buying a microphone, it is essential to make sure that it will do the job you want it to do. This means that you have to clearly understand which application(s) the microphone was designed for.

There is no such thing as an all-purpose microphone that is ideal for every application. Differences in pick-up pattern, maximum SPL constraints and noise floor should all be taken into account during the selection process. All microphones are made for a certain purpose or sometimes a compromise between several related purposes.

Is it primarily for recording in a studio or home studio, is it for live use or perhaps both? Is it meant for one specific instrument or sound source or should it be for more general use? Is it to be mounted on a stand, an instrument, a head or is it handheld?

Is your budget limited? Quality always costs. You can save money on features you don't need, but to most people quality is a feature they do need.

Live vs. studio miking

The main difference between these two environments is not the sound source itself but the surroundings.

The studio is a relatively controlled environment, where you often are given a second chance if the result is not satisfactory. For that reason your expectations of the result will, of course, also be much higher. That means the desire for clarity, definition and low noise has no upper limit.

In order to compensate for poor sounding acoustics or to get more channel separation when multiple instruments are recorded, directionality can be more important than definition and noise.

The main problem with a live setting is the large number of other loud sound sources other than the one you wish to amplify or record such as the P.A. front and the monitors that can cause feedback, or the other musicians and their amps that are often much louder than the voice or softer instrument you need to mic.

This means that the primary objective for a live microphone is separation and secondarily good off-axis sound (sound taken in from the side/back of the microphones).

If the monitor and amplifier level on stage is controlled and relatively low, it is possible to gain more clarity and definition by using less directional microphones.

Dynamic vs. condenser mics

Dynamic microphones are, in brief terms, a reverse dynamic loudspeaker (you can actually use a loudspeaker as a dynamic mic – don't try the opposite). It's a moving coil in a permanent magnet. The diaphragm is attached to the coil, and when it moves, it produces varying current through electromagnetic induction.

The construction of dynamic mics is quite simple, which makes them rugged and inexpensive and they don't require external power. The rugged heavy construction also makes them more 'forgiving' with less resolution. Most common applications are live – especially on vocals, drums and amplifiers.

A condenser microphone consists of a capacitor, where one side is the diaphragm and the other is the back plate which is polarized either from an external power source or by prepolarization. As the diaphragm moves it changes the capacitance, and these changes are then amplified to make a transmittable signal.

All condenser mics need external power (referred to as phantom power) to energize the internal electronics. They produce a sound signal of a much higher quality than the dynamic mics, but they are more expensive, and a little more fragile to use, however newer technology has made them far more resistant to rough use, and the use of condensers in live applications is on the rise.

Testing your microphone

Never test a microphone alone. It's always easier to hear a microphone's character if you compare it to something.

It is important to keep in mind that the acoustic memory of the human being is only a few seconds. You can't rely on your memory of a microphone you tried last week, you need to be able to switch back and forth – A/B-testing. You can either test against an alternative microphone you are considering buying or one of your own microphones that you are very familiar with.

Compare their on-axis sound. For a studio microphone this can be done at two different distances: 30 cm, which is the normal distance when recording a vocal, and for further testing, 3 cm on a loud sound source to check its upper dynamic range. If it's a directional microphone, this will also help to check proximity effect and pop noise (more about this later).

For all microphone testing using a really challenging sound source can be very revealing. Try testing with a large ring of keys. The sound of jangling keys has some very complex high frequencies that are difficult to reproduce. Good mics can, but lesser mics sound like you are crumbling a piece of paper.

To test a live microphone you wish to hear its performance in its normal environment, so standing in front of a P.A. facing the stage would be ideal. Place the microphone as it will normally be used, usually very close to the sound source, and again always test multiple mics at the same time.

In live use gain before feedback is very important. You therefore need to test at quite high volumes to see which microphone feeds back first.

Next compare their off-axis sound. On directional microphones you need to check the suppression of off-axis sound. How hard is the suppression and – also very important – how good it sounds.

For live use you generally want as much suppression of off-axis sound as possible. You only wish to hear the sound source itself. But very hard suppression often gives a very uneven off-axis sound that will give the impression of 'unnatural' sound reproduction.

Usually this compromise relates to the genre of music you play. An acoustic low volume genre really appreciates an open, natural and clean sound, whereas the louder the volume and the higher the need for gain before feedback, the higher tolerance towards 'unnatural', amplified sound.

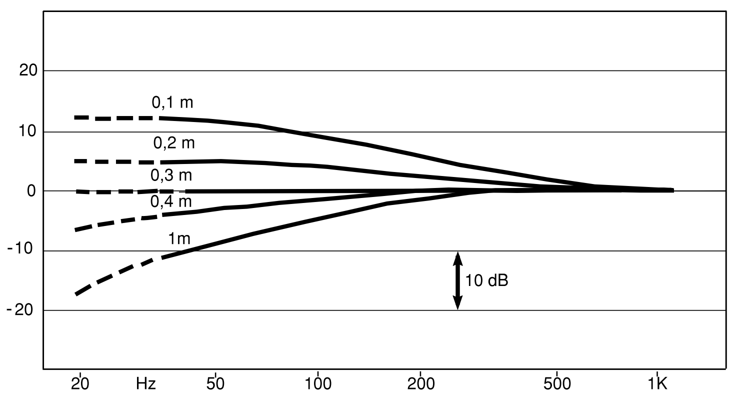
Directional/cardioid vs. omnidirectional microphones

Microphones can have different directional characteristics. Omnidirectionals that pick up the sound all around them, and cardioids that mainly pick up the sound directly in front of them. Other directional patterns are: bidirectional/figure 8, supercardioid, hypercardioid, and wide cardioid.

Generally a cardioid sounds appealing, since in a musical setting you only want the sound source and rarely want to record or amplify the surroundings. But directionality has a price and that sometimes is not worth paying.

Directional microphones need to have a much softer diaphragm than an omni. This softness results in handling, pop and wind noise which puts a limit to how close you can get to a vocalist, even when using pop-filters.

A directional mic also suffers from proximity effect, which means that the closer you get to the sound source the louder the low frequencies get and vice versa.



The proximity effect exhibited by the DPA 4011-TL Cardioid Microphone.

DPA MICROPHONES

A cardioid microphone can be adjusted to be linear at the distance it is normally used. A vocal microphone for live use, for example, is adjusted to be linear at a distance of approximately 1 – 2 cm and at longer distances the low frequencies drop dramatically. A studio microphone is typically adjusted to work at a longer distance.

In the example of the DPA 4011-TL, when used closer than 30 cm it gives a low frequency boost, and when used further than 30 cm it gives a low frequency roll-off. That means that from any other distance than 30 cm equalization is needed unless the proximity effect is desired.

Additionally the off-axis sound of a cardioid is less linear than that of an omni. It is very hard to reduce the level of sound taken in from the sides without some coloration, and some directional microphones have a notably poor off-axis response.

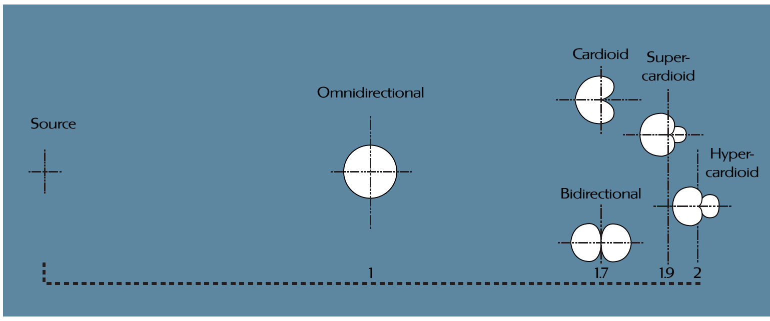
This means that sound entering the microphone from the sides and the rear are more or less strongly colored – the industry names this "the curtain effect". This effect can be seen on the microphones polar pattern as 'spikes'.

On the other hand, miking live with high level monitors can make the omni mic feed back, which makes the cardioids more suitable for this application, although the use of in-ear monitors reduces that problem.

Polar pattern	Omnidirectional	Directional
Gain to feedback ratio	Lower	Higher
Feedback buildup	Slow	Fast
Off-axis coloration	Smooth and even	Typically less smooth
Proximity effect	No	Yes
Sensitivity to wind, handling and pop noises	Lower	Higher
Distortion	Lower	Higher
Channel separation	Near field: Good Diffuse field: Less precise	Near field: Good Diffuse field: Good

If you choose an omnidirectional microphone, channel separation may be less precise than with a directional microphone, because the omni will pick up sound from all directions. Therefore, if channel separation is preferred, the ratio between direct and indirect sound can become more unfavorable with an omni.

The omni, however, can be moved closer to the source, without the penalty of proximity effect. As a general rule it can be said that if we place a cardioid at a distance of 17 cm to the source, then an omni placed at 10 cm gives the same ratio of direct and indirect sound as the cardioid.



Relative distance to sound source for equal balance between direct and indirect sound.

Multi-pattern microphones with both omnidirectional, bidirectional and cardioid characteristics will always compromise the sound quality. It may be very convenient to have a 3-in-1 solution, but the drawback is reduced performance in each mode.

Due to the need of a pressure gradient design, a multi-pattern microphone in omni mode has many of the weaknesses of the cardioid, such as popping, handling and wind noise and a less linear off-axis sound. In fact a multi-pattern microphone in the same mode can have different characteristics depending on the frequency.

Large vs. small diaphragms

Before choosing between a large and a small diaphragm microphone it is important to know the difference in features between them, and microphone behavior can not be compared with that of a loudspeaker when considering size.

A large diaphragm microphone is not better at reproducing low-frequencies, but it may be less precise in reproducing high frequencies, which may make it sound as if it has more low end.

A small diaphragm has a higher self noise due to the fact that the small diaphragm is less compliant and therefore more sensitive to the bombardment of air molecules that causes some of the self noise of a microphone. And since the large diaphragm is softer than the small, it is easier to move and therefore more sensitive – even at very low levels.

This means that the small diaphragm, because it's stiff, can handle a higher sound pressure without clipping or distortion, but is less sensitive and needs more amplification, which also adds a little noise.

When reproducing very high frequencies, large diaphragm microphones have a more limited range than the small diaphragms. This is caused by three factors:

1. A large diaphragm tends to break up and will no longer act as a true piston. This phenomenon is also recognized in loudspeaker technology and is the reason why loudspeakers are manufactured with different sizes of diaphragms to handle different frequencies.

2. The weight of the diaphragm will attenuate the displacement of the diaphragm for higher frequencies.

3. The diffractions around the edges of the microphone capsule will limit the microphone's capability to handle very high frequencies.

Conclusion
Both diaphragm sizes have their respective advantages and disadvantages. This is illustrated in this table, which compares the specifications of DPA's small and large diaphragm microphones:

	Small diaphragm	Large diaphragm
Self Noise	Higher 4004/4007 - 24 dB (A)	Lower 4003/4006 - 15 dB (A)
Sensitivity	Low 4007 - 2.5 mV/Pa	High 4006 - 10 mV/Pa
SPL Handling capability	High 4007 - 155 dB SPL 4004 - 168 dB SPL	Lower 4006 - 143 dB SPL 4003 - 154 dB SPL
Frequency Range	Wide 4007 - 20 Hz - 40 kHz +/2 dB 4004 - 10 Hz - 40 kHz +/2 dB	Narrower 4006 - 20 Hz - 40 kHz +/2 dB 4003 - 10 Hz - 20 kHz +/2 dB
Influence on sound field	Small	Large

Both diaphragm sizes have their respective advantages and disadvantages. This is illustrated in the table above.

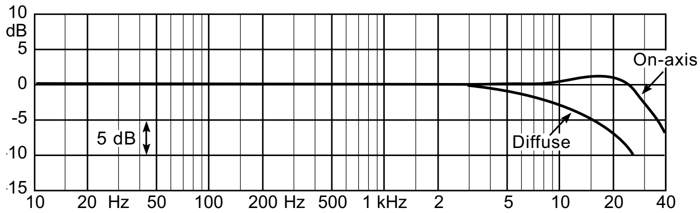
How to read mic specifications

When you read microphone specifications in order to compare different microphones, it is extremely important that you understand how to interpret them.

In most cases the specifications can be measured or calculated in many different ways. This article is designed to help evaluate specifications in a meaningful way.

While microphone specifications provide an indication of a microphone's electro-acoustic performance, they will not give you the total appreciation of how it will sound – just as it is with cars. Knowing that it is a 3.0 turbo-engine with 4WD gives you an idea of a pretty good driving experience, but for the exact feeling, you need to drive the car yourself.

Frequency range/frequency response
Frequency range tells you the range of the frequencies (for example 20 Hz to 20 kHz) that the microphone can pick up and reproduce, but not how well the different frequencies are reproduced. To see that you need the frequency response:

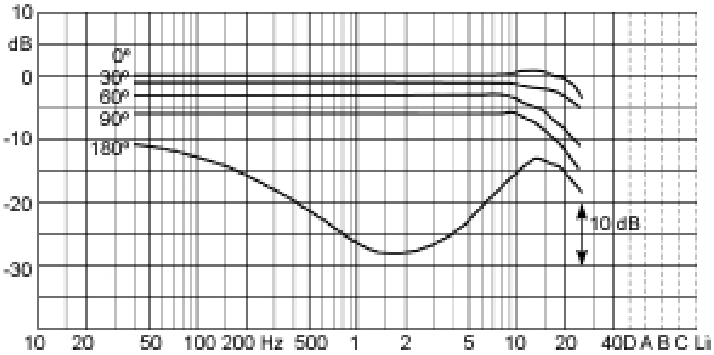


Frequency response of DPA 4006 Omnidirectional Microphone, P48.

Here you see how linear the response is or if the microphone has any 'spikes'. But pay attention to the scale on the left. The number of dB each step represents can vary a lot.

The frequency response normally refers to the on-axis response, which means from a sound source right in front of the microphone. The diffuse field response curve will illustrate how the microphone will respond in a highly reverberant sound field.

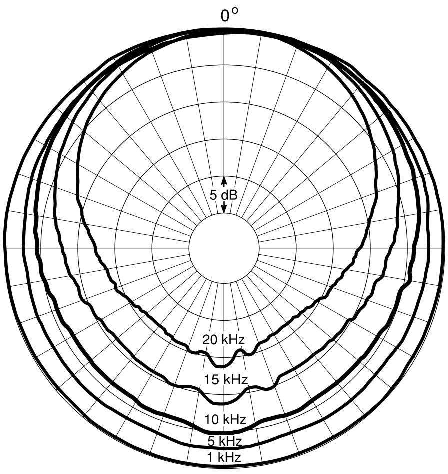
It is also important to examine the off-axis response. A microphone always takes in sound from the sides too, the question is just how much and how good it sounds. In particular, directional microphones can, in their attempt to suppress sound from the sides, get an uneven off-axis response:



On- and off-axis responses of DPA 4011-TL/4012/4021/ 4022/4023 cardioid microphones measured at 30 cm.

Finally a polar plot can show the 360° response of selected frequencies. The response curves should be smooth and symmetric to show an uncolored sound. Extreme peaks and valleys are unwanted and the response curves should not cross each other.

From the polar diagram you can also see how omnidirectional microphones usually become more directional at higher frequencies.



DPA 4006 Omnidirectional Microphone.

Equivalent noise level/self noise
The equivalent noise level indicates the sound pressure level that will create the same voltage that the self-noise from the microphone will produce. A low noise level is especially desirable when working with low sound pressure levels so the sound will not "drown" in noise from the microphone itself. The self-noise also dictates the lower limitation in the microphone's dynamic range.

There are two typical standards:
The dB(A) scale will weight the SPL according to the ear's sensitivity, especially filtering out low frequency noise. Good results (very low noise) in this scale are usually below 15 dB(A).

The ITU-R BS.468-4 scale uses a different weighting, so in this scale, good results are below 25 dB.

Sensitivity, sound pressure level (SPL) handling and total harmonic distortion (THD)

Sensitivity tells you how well the microphone can convert the acoustic sound into electricity and according to the IEC 60268-4 norm, the sensitivity is measured in mV per Pascal (air pressure) at 1 kHz. The higher the sensitivity the better, because it reduces the need for amplification and therefore reduces the amplification noise.

SPL handling tells you how much sound pressure in dB the microphone can handle before it either clips (the diaphragm hits the backplate or the amplifier overloads) or reaches a certain level of distortion (THD or total harmonic distortion). Typically either 0,5 % or 1 %. The higher level of sound pressure before clip or distortion the better.

Example:
DPA 4004 Hi-SPL Omnidirectional Microphone, 130 V:
Maximum sound pressure level: 168 dB SPL peak
Total harmonic distortion: 142 dB SPL peak (<0.5 % THD), 148 dB SPL peak (<1 % THD)

Conclusion

We sincerely hope this microphone guide will be helpful to you, and make you aware of what to look for when buying your next microphone.

We know it's a very technical field, but we are convinced that today's musicians and home studios have demands just as high as sound engineers and producers, and so need the same level of knowledge.

For a deeper exploration of these topics, please refer to other sections of the Microphone University.

Microphone University

DPA's online Microphone University is your pro audio learning center, providing a wealth of articles discussing all things microphone.

Subjects include basic technical information, microphone placement, applications, stereo and surround recording.

Application Guide

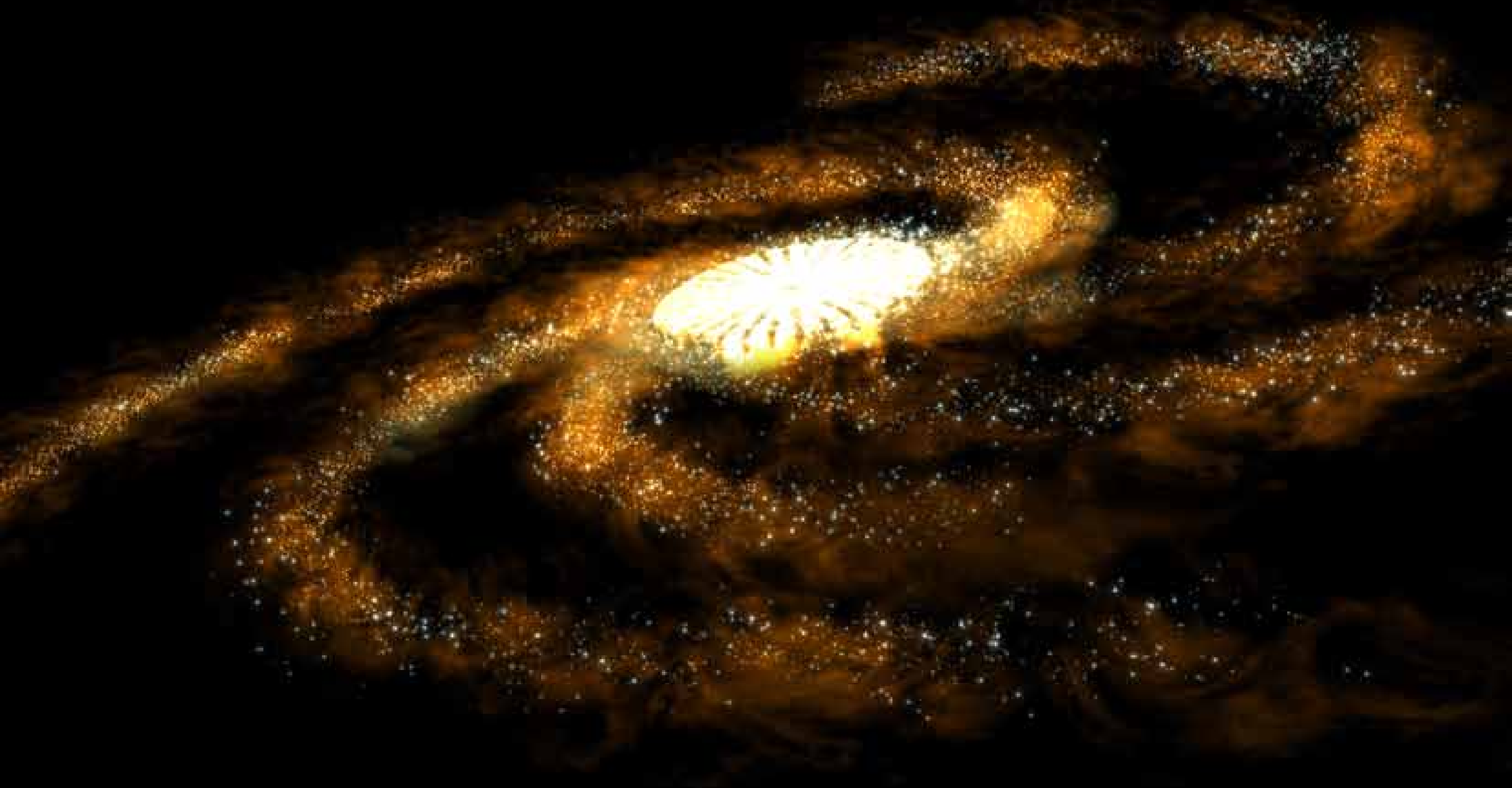
The Application Guide offers useful tips about which microphones to use and how to use them on a variety of instruments.

From acoustic guitar and banjo to trumpet and violin, this guide shares tips on how to find your instrument's sweet spot.

Microphone Guide

Whether you are a recording musician, a Foley artist, or an audio engineer for a house of worship, the DPA Microphone Guide is a great place to start.

There is a DPA microphone for every job – use the Mic Guide as a quick and easy way to find the right one.



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