Translated from Germany's

Die technische Dimension von HiFi

stereoplay

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Managing Conductors

Do cables affect sound, and if so, why? *stereoplay* investigates these questions with the most elaborate test in recent years. Our results are made available to everyone - with downloadable HiRes tracks for comparison.

The theme of cable sound has a long tradition with *stereoplay*: in the late 1980s, we dealt - then as now on the so-called "Blue Pages" - not only with the effects, but also with the technical background. Unforgettable, for example, is our premium series "The Demystification of Cables" by Horst Kiesewetter, particularly the profiled cable developer of Audio Sound Company, which merged later into Hama.

Consistently and successfully we were also reporting on the cable issue in the early 90's. Our workshop "The Self-Made Speaker Cables," which described a cross interconnected computer ribbon cable, was a great hit. Not without pride, *stereoplay* can take claim for themselves as key pioneers of low-inductance speaker cable. It is a construction method that has validity today and has helped some manufacturers who were newcomers at that time, and has made them into successful market players - as HMS, Kimber and Nordost.

Of course we encountered stumbling blocks on our way: for example, *stereoplay* developed in 1994 for experimental purposes a technically perfectly matched speaker cable with superior after filtering and impedance point of measurement values. In listening tests, however, it did indeed sound very neutral and clean, but no better than a comparison cable with significantly less favorable values - a clear indication that our hitherto exclusively based on impedance and filter model approach was not sufficient for audio cables.

The Cable Comparator from specialists Wireworld allows small signal cable AB listening tests in comparison to a direct connection. Its electrical construction is absolutely uncompromising.

The same trend was evident in small-signal cables, which serve the powerless, analog signal transmission of audio components to one another: The electrical impedance and moderate adaptation to the transmitter and receiver is also significant with them - but impedance linearity alone cannot guarantee that a cable will sound good.

Can cable sound be measured?

Twenty years ago *stereoplay* tried via extensive measurements on some 500 small signal cables all kinds of correlations between the identified values and their sonic properties - without significant success. However, this action was not completely in vain, as we developed reliable methods for measuring the one meter standardized values that we publish, along with producing a database of starting values to serve additional investigations.

For physical reasons, all cables have next to the ohmic series resistance R always also some parallel capacitance C (capacitor effect) together with a series inductance L (coil effect), wherein the series resistance is a function of the cross-sectional area of the conductor material, while parallel capacitance and series inductance depend on the architecture of the cable. The fourth parameter is the conductance G, which is the reciprocal value of the insulation resistance separating the forward and return conductors electrically from each other.

These four variables R, L, C and G, together, as electrical components considered a kind of lossy low-pass filter (see chart on page 122 below). In the beginning of the 90s *stereoplay* projected the concept that mapping these four parameters according to generally accepted doctrine could predict the sound of cables. However, we were unable to confirm this thesis by correlating the measurements with our listening tests.

Of course, a good cable should be also be optimized according to its intended use (small signal, speakers or digital). Amplitude losses can be minimized to avoid phase shifts at high frequencies. This especially applies for longer cable lengths above five meters, such as in the recording studio, but not in the hi-fi, where short interconnects prevail. At those lengths they are a pure filter and impedance analysis of the cable is not effective because the dominant factors in small signal cables do not include the parallel capacitance, simply because it is usually much too low.

Working with the Wireworld Cable Comparator requires special attention at installation, as it needs to be cantilevered between source and receiver, facing back to back.

Loss Factors and Co.

We received the first really promising note on a possible correlation between readings and listening results with a test of speaker cables in 1998. With a borrowed, very high quality Wayne Kerr measuring bridge, test frequencies in fine steps to up to three megahertz could produce documented. We then had all test takers meticulously following the listening test. It was noticeable that the highest fidelity cables were those with relatively a low, but - even more important – the most uniform inductive loss factor.

That sounds complicated, but is easily explained: The inductance (coil effect) of a cable exists only theoretically

Measurements

Since the cable parameters vary greatly by frequency, we have measured the test participants each at four frequencies: 100 Hz, 1 kHz, 10 kHz and 100 kHz. The LCR measurement bridge was a calibrated Agilent (formerly HP) 4263 A, which thanks to four-pole measurement, is very accurate. Note that these values were measured including the connectors. Their influences are not negligible, because only cable lengths of about one meter were available - therefore a mere multiplication of the values for longer lengths does not provide absolutely correct results. Although the measured values fit within the expected range, there were distinct differences. Striking here is the Van den Hul, which due to the carbon fiber conductors has relatively high series resistance of about 5 ohms. The Clear Audio and Cardas cable's parallel capacitances of about 200 picofarads per meter make them less suitable for longer cable runs.

in pure form. in practice it is, by contrast, influenced by various losses preventing the flow of the voltage is not lagging exactly 90 degrees as described in textbooks, but for example only 88 degrees out of phase. The missing two degrees one speaks of as the loss angle. However, that is not directly specified, but as a loss factor D (∂ tangent = opposite leg / The adjacent side to the electrical phasor diagram). These frequency-dependent inductive losses may be are more or less pronounced in each cable. One significant polluter is the so-called skin-effect (see adjacent box), which can be minimized for an associated decrease in the inductance.

Skin Effect

The higher the frequency to be transferred, the more the current tends to flow only on the surface a conductor. The current flow is displaced by its electromagnetic interaction inside the wire. The skin effect plays a very significant role at radio frequencies above about 150 kHz, however, it is also noticeable at the top end of the audio frequency range in cables. An alternating current of 20 kHz, for example, in a loudspeaker cable with 6mm² cross-section (corresponding to diameter of 2.8mm) flows, has only an E penetration depth of 0.46mm - which means that the current flows through only 3.2mm² rather than the original, 6mm² available with direct current. The cross section is effectively almost halved and that is why the series resistance almost doubled! For all that accurately want to know, here the formula for self-recalculating:

$$e \approx 15.9 \cdot \sqrt{\frac{\rho}{\mu_r \cdot f}}$$

with e in millimeters, rho in Ωmm²/m, f in kHz

μr is for copper, silver and gold = 1 set

rho (copper)
= 0.01724 Ωmm²/m
rho (Silver)
= 0.01612 Ωmm²/m
rho (Gold)
= 0.02222 Ωmm²/m

One can clearly recognize that cables with especially thick inner conductors are surely at a disadvantage with skin effect. You can circumvent this only with individual conductors whose diameter is less than twice the penetration depth in the highest frequency to be transmitted.

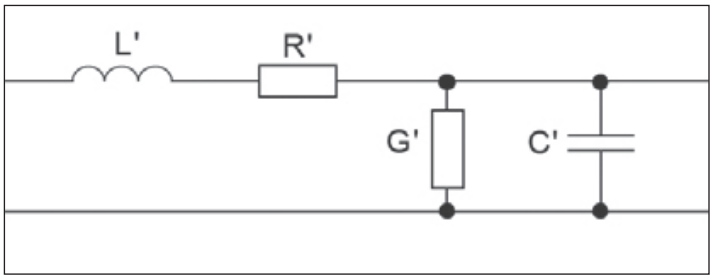
Series Resistance and Inductance

Because speaker cables transfer electrical power, the current levels are far more significant than for interconnects. Therefore, the series effects, resistance R and inductance L (with the appropriate losses) are of primary importance. On the other hand, interconnect cables work more predictably, because they only transfer electrical voltages. For this reason, the parallel capacitance C and conductance G is of particular interest. So there is a counterpart to the inductive dissipation factor D with speaker cables - the capacitive loss factor. And that is a hot topic for *stereoplay*, because it could be the key for different sound with small signal cables. However, quantifying its impact with short cables has been elusive.

An interesting statement this comes from Roger Skoff, the founder and former developer of XLO Cable: "I am always amazed that experienced engineers often ridicule the concept of cable sound, but then embrace the technical and tonal advantages and disadvantages of different capacitor types - although in this case essentially the same issues are addressed."

He is right, because the properties of the insulation material between the conductors, called dielectric, play a significant role, especially for interconnect cables. It would be best to have air (due to its low dielectric constant) between the conductors, followed by expanded PTFE (Teflon), fixed - or even cheaper - foamed polyethylene (PE) and polypropylene (PP). polyvinyl chloride (PVC), however, is good at most as the outer cable jacket, but not as a dielectric.

The topic of conductor material could be discussed endlessly. Copper provides the best compromise between cost and electrical conductivity in that the series resistance of the cable is significant. Copper can be said to be like olive oil in that a chemical analysis of several brands one finds actually always



Electrical equivalent circuit of a line: The typical characteristics, series resistance R, series inductance L, shunt capacitance C and conductance G are shown here as separate components. This is often used as a representation of lossy low-pass filter but it's not helpful in understanding the cable sound phenomenon.

the same ingredients, but they do taste different. All copper is not created equally, as the raw material and the manufacturing method have an effect on the quality, even if the resistivity is identical.

Through countless listening tests, *stereoplay* has experienced differences between the sound of copper and silver. Silver can improve fidelity, especially if the conductors are solid silver. On the other hand, if the layer thickness of silver plated copper conductor is too low, a rather unfavorable tilt in the treble range brightens the sound. In those cases, it appears that skin effect is making different propagation speeds noticeable.

How Do Cables Affect Sound?

At this point, those inexperienced with HiFi and seasoned electrical and communications technicians usually find it difficult to suppress their skepticism. How does "cable sound" manifest itself and in which order of magnitude are differences possible? Pursuing these matters of fact is worthwhile and there are amazing observations to be explained. For example, why are the sonic effects of speaker and interconnect cables so similar when the technical framework of their applications is so different?

An analogy to optics helps explain the effects and focus attention on listening to specific criteria: The sonic differences among cables express themselves in a way similar to adding various types of glass sheets between the eye and an object. Cables can behave as extremely transparent or as rather dull panes, and there are also tinted or colorless panes. In addition, there are also spotless, soiled or lightly foggy panes.

The optical analogy applies to the acoustic considerations in the following way: Each cable disclosed in an existing play-chain its own detail and its own sharpness. However, one must be careful because similar effects are created with TV sharpness controls, which subjectively improve sharpness through equalization. Similarly, a cable that adds metallic brightness to the sound may seem to reveal more information, but the sound becomes artificial.

Spatial Extent of the Sonic Image

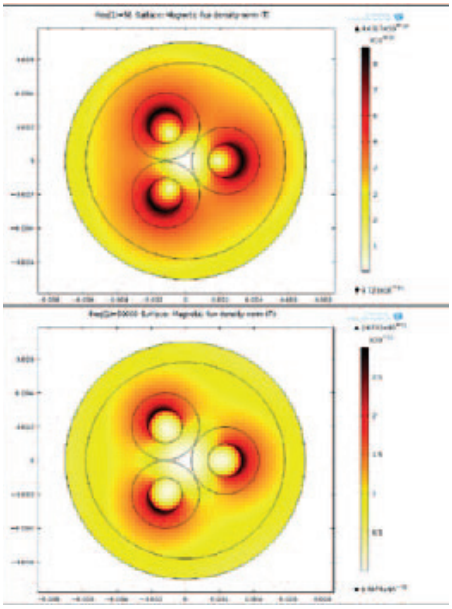
It's always amazing to hear how different cables influence the spatial extent of the entire sound image so strikingly. There is a certain similarity

Cable Sound - The Facts

At *stereoplay* we used to think that cable sound was mostly caused by electrical filter behavior, but after hundreds of tests and measurements, we found that only a fraction of the listening test results could be interpreted that way. Today Stereoplay is sure that a crucial factor lies elsewhere: Namely that the conduction of direct current and high frequency current are two relatively different states of operation.

For each state, different perspectives of signal transmission apply. This dichotomy has proven disruptive, not only because the functions differ, but because they continuously vary in response to the signal. For the transmission of audio signals through cables, the lowest frequencies approach direct current operation, while highest frequencies are subject to a complex blend of losses. In between are ten octaves within which the cable parameters shift dramatically between the one and the other extreme, as the measurements always confirm.

Only the audio field requires cables to cope with such a balancing act. For example, the influence of the skin effect as a frequency-dependent increase in series resistance across the audio range varies far more than that of a high frequency antenna cable, in which even a doubling the transmission frequency causes virtually no further increase in series resistance. In our estimation, it is the non-linear frequency-dependent parameters such as skin effect, proximity effect (current displacement by adjacent conductors), eddy currents and dielectric losses have the greatest impact on cable sound. As with skin effect, proximity effect also increases the inductive loss of high frequencies - but its influence is usually somewhat lower. With the usual electrical cable models, mapping proximity effect is relatively imprecise. In recent years, new scientific techniques are improving this: particularly exciting is the representation in the form of finite element models (see chart above).



Frequency-dependent effect of Proximity effect in three parallel conductors with the same current flow direction

to the sonic losses of digitally compressed music: While the tone color losses are often neglected, they can produce marked differences in musical presence: An open, detailed, expansive sound binds the listener more emotionally to the music. In this sense, a cable upgrade may initially sound relatively unspectacular, yet the changes can plant the all-important kick of lifelike fidelity to music playback.

Small Differences

Even if the audio cable manufacturers like to describe cable differences in orders of magnitude, they're not as critical as speakers or even acoustic modifications of the listening room. Nevertheless, a middling CD-player with a good cable can outperform a top player with only a modest cable.

Here again, an optical analogy is helpful, as lenses ultimately have a greater impact on achievable image quality than sensors. It can also be expressed differently: If you measure by Luxmeters the illuminance at a workplace, is the value with a slightly dirty lens compared to an absolutely clear glass not changed? Also, while looking out the same viewing angle, you may see details not seen before. An absolutely pure, non-tinted lens has a much more immediate impression of everything - even when technical measurements show nothing has changed.

The insights we've gained so far show that the much vaunted sound tuning systems with targeted use of "cable sound" is a rather two-edged sword - because the cables emphasis of certain sonic properties cannot exist without creating disadvantages elsewhere. Consequently, *stereoplay*'s top rated cables in the listening tests are therefore always the most neutral, detailed and dynamic - and this will remain so in the future.

The Cable Dilemma

In general, the motto is 'the best cable is none at all'. Nonetheless, very fine sonic details may also be heard with the absolute top cables, which avoid the risk of serious coloration and losses.

The real problem in audio cables is that from the outside, one cannot predict their fidelity. Indeed, even cables made with good materials and manufacturing processes often provide less than good results. How well the cables perform depends solely on the expertise of the developer. The fact that their function at first glance seems almost trivial and they always "somehow" make music, has seduced some inexperienced individuals to go into the audio cable business hoping for easily-earned Euros.

No-Name Products or Brand Cable?

For the audio customer, a cable purchase is a matter of trust. No-Name products are

Standard 'In-the-Box' Cable

In direct comparison to the short jumper, the beginner cord sounded decently balanced, however the mid-range and presence region appeared milky, opaque and congested. In this comparison it was virtually the zero line at which we oriented ourselves.

Measurements (1 kHz): R = 121 mΩ; L = 440 nH; C = 99,6 pF; G = ,0006 µS

stereoplay Test Verdict

Fidelity Grade	(1)
Sound	Sufficient
Value	Very Good

stereoplay Highlight

Mogami Excellence

330 Euro

The Mogami offers subtle unexcited, still fine, very detailed Play. It just sounded in an unspectacular way "right" and gave - no matter in which music material - always the right Sound with convincing natural spatiality.

Measurements (1 kHz): R = 42,2 mΩ; L = 330 nH; C = 77,5 pF; G = ,0004 µS

stereoplay Test Verdict

Fidelity Grade	(13)
Sound	Outstanding
Value	Outstanding

Oehlbach Black Connection MXXL

380 Euro

The Oehlbach provided especially lively play. In the low frequencies it is quite bulky and full bodied with rather soft character. The upper frequency range was quite clearly emphasized and sounded a bit artificial.

Measurements (1 kHz): R = 50 mΩ; L = 350 nH; C = 71,9 pF; G = ,0001 µS

stereoplay Test Verdict

Fidelity Grade	(9)
Sound	Good
Value	Good

stereoplay Highlight

Kimber Kable Timbre

400 Euro

Among the test candidates the Kimber exhibited the clearest character: It sounded impressive, precise, with sharp outlines and stable focus. Details were produced very clearly, without grit. Very spectacular, very informative - A real wow factor with quite vivid presence.

Measurements (1 kHz): R = 34,2 mΩ; L = 360 nH; C = 74,6 pF; G = ,0003 µS

stereoplay Test Verdict

Fidelity Grade	(14)
Sound	Outstanding
Value	Outstanding

Legend: = Neutral = Warm, Bass Heavy = Cool, Spacious, Sharp

A short jumper between D/A and A/D transducers simulating operation without an interconnect cable.

Here a standard CD player is playing through the direct connection to the A/D converter.

not necessarily inferior, but the probability that branded cable specialists offers higher quality, is much greater. As already mentioned, even though there may be a direct relationship between the material cost of audio cables and their selling price does not necessarily mean that the more expensive cables provide higher fidelity.

A seriously valuable guide can be provided by cable tests in journals - such as presented here, in which we have gathered for comparison a group of interconnects in the "sanity price range" of 500 Euros for laboratory and listening tests. This was also an ideal opportunity to test our now proven listening panel "Friends of *stereoplay*" by coming together again to produce the listening tests. Thus, the results do not represent personal individual statements, but reflect the combined hearing perceptions of the entire panel.

Chord Company Anthem Ref. 2

450 Euro

The Anthem Reference 2 was profiled in the listening test with an especially lively style of play, with unrestricted dynamics, but surprisingly the midrange sounded rather reserved.

Measurements (1 kHz): R = 38,4 mΩ; L = 470 nH; C = 181 pF; G = ,0006 µS

stereoplay Test Verdict

Fidelity Grade	(9)
Sound	Good
Value	Good

Cardas Audio Parsec

460 Euro

With a beautifully layered spatial impression, open and clear sound, particularly in the midrange. Not to mention the fine Treble - wrote the tester favorably on the Cardas Parsec. Overall, the bass is rather full and plump.

Measurements (1 kHz): R = 223 mΩ; L = 460 nH; C = 217 pF; G = ,0018 µS

stereoplay Test Verdict

Fidelity Grade	(10)
Sound	Very Good
Value	Good

Straight Wire Expressivo

475 Euro

The Straight Wire was described as tasty in the listening test with its luminous and pleasing effect that we'll rewrite with the term "tasteful". The representation of space was convincing. On top of that there was plump, rich bass.

Measurements (1 kHz): R = 19,5 mΩ; L = 220 nH; C = 133 pF; G = ,0003 µS

stereoplay Test Verdict

Fidelity Grade	(11)
Sound	Very Good
Value	Good

Van Den Hul 3T The Rock

500 Euro

The Van Den Hul was ambivalent in the listening test: With smooth, natural mids resulting in a stress-free, "Musical" impression. On the other hand, it sounded dark with a lack of presence and there was something missing in the bass.

Measurements (1 kHz): R = 5,3 Ω; L = 1230 nH; C = 91,7 pF; G = ,0004 µS

stereoplay Test Verdict

Fidelity Grade	(8)
Sound	Good
Value	Satisfactory

Legend: = Neutral = Warm, Bass Heavy = Cool, Spacious, Sharp

Downloadable Listening Tests

To provide an even broader basis for the listening test results, we also had the test takers make the same comparisons with headphones. Beyond that, we are giving our readers the opportunity to make the same comparisons with the 24 bit/96 kHz-HiRes files available as a free download from, **http://www.stereoplay.de/kabelvergleich**.

To ensure that the audio signals flowed through the test cables and not a possible detour, we used two independent systems for the playback and recording path. Playback of the 24-bit master (the Song "Kehleri" of Annuluk, www.annuluk.net) was performed via Pure Music 2:02 with the DAC AMI Music DDH-1 (tested in issue 1/14): This was connected through each of the test cables to the RME Fireface ADC, from which it arrived into the Pro Tools recording system. To demonstrate that good cable even has a positive effect on average hi-fi components, we have prepared the same master file and a normal CD over a fairly elderly NAD C 542 played for recording. As a "reference standard" you will find the test candidate files also our reference cable Wireworld Platinum Eclipse.

One of the most serious considerations for expensive cables is the thesis that they can sound different on different systems. Therefore,

in-akustik NF-1203

500 Euro

The In-akustik played freely and dynamically in the listening test. With its clear presence, it was not unlike the Kimber in the spectacular direction, but with less homogeneous and structured mids. "Frantic Rocker" wrote one tester.

Measurements (1 kHz): R = 232 mΩ; L = 750 nH; C = 46,2 pF; G = ,0001 µS

stereoplay Test Verdict

Fidelity Grade	(10)
Sound	Very Good
Value	Good

Goldkabel Executive Rhodium

500 Euro

With its balanced, detailed play earned the gold wire ample advantages in the listening test. With high resolution and precise space representation it was not unlike the Mogami, but offered not quite as magnificent timbres.

Measurements (1 kHz): R = 95 mΩ; L = 410 nH; C = 68,4 pF; G = ,0003 µS

stereoplay Test Verdict

Fidelity Grade	(11)
Sound	Very Good
Value	Good

Clearaudio Sixstream Plus

520 Euro

"Balanced, round, neutral - But no wow factor " wrote it one of the testers in the Clear Audio test profile. By this he meant that it is quite clean and structured, but like the generic cable its overall sound is somewhat congested.

Measurements (1 kHz): R = 243 mΩ; L = 540 nH; C = 217 pF; G = ,095 µS

stereoplay Test Verdict

Fidelity Grade	(8)
Sound	Good
Value	Satisfactory

Audioquest Water

550 Euro

With 72 volts DC bias on the insulation material between the conductors to avoid dielectric losses, the AudioQuest reproduced the voice pitch contours, but sounded slightly withdrawn overall.

Measurements (1 kHz): R = 61 mΩ; L = 750 nH; C = 71 pF; G = ,0006 µS

stereoplay Test Verdict

Fidelity Grade	(7)
Sound	Good
Value	Sufficient

Silent Wire NF 8 MK2

580 Euro

It took only a few bars for the Silent Wire to prove a favorite among the jurors. Balanced, resolved, open clear, present, dimensional - Hailed from all sides with good attributes. A finer midrange would have made it a top contender.

Measurements (1 kHz): R = 192 mΩ; L = 970 nH; C = 57,7 pF; G = ,0002 µS

stereoplay Test Verdict

Fidelity Grade	(13)
Sound	Very Good
Value	Good

Wireworld Eclipse 7

stereoplay Referenz

450 Euro

Stereoplay's "Top Dog" in the 500€ class. Reviewed in issue 6/2013, it convinced us with fantastic resolution and vitality that reminds us of the grand Platinum Eclipse. No other cable in the competition could even get close to the performance of the Eclipse 7.

Measurements (1 kHz): R = 60,5 mΩ; L = 170 nH; C = 382 pF; G = ,001 µS

stereoplay Test Verdict

Fidelity Grade	(15)
Sound	Outstanding
Value	Outstanding

Legend: = Neutral = Warm, Bass Heavy = Cool, Spacious, Sharp

For the listening test files, individual 24/96 stereo overdubs were created with each cable. There are two passes with 24 and with 16-bit sound source (CD).

How *stereoplay* Tested Interconnect Cables

Part of the crew during the intensive listening: Marco Breddin, Jürgen Schröder, René Heller and Michael Maerkl (in the background).

stereoplay used three different test configurations. The test cable came first between the Reference CD player Ayre CX 7e and the precursor Octave HP 300, 2) between the full-size CD player NAD C 542 and the Brinkmann Amplifier and 3) between the TEAC CD player PD-501 HR and the headphone amplifier B.M.C. Pure-DAC. Result: The results were all together consistent. The AudioQuest sounded harmonious in all chains, but dynamically compressed; Van Den Hul appeared always somewhere in the middle. Since the differences are comparatively small, all passages were repeated several times for several days.

The comparison files are very helpful with such low differences. At www.stereoplay.de, you will find HiRes tracks of all test cables and a direct reference file that has been recorded on an ultra-short bridge wire. For an especially convenient way to take the cable listening tests, load all files on a multi-track audio program (for example, the free Audacity) on your computer and the through the mute function, deactivate all tracks that you do not currently need to compare.

In addition to the listening tests and measurement results we were naturally interested in how manageable the test cables were in use. Here there was not all sunshine and roses: For example, some of the test cables (AudioQuest, In-akustik and Straight Wire) proved to be extremely inflexible or so thick that they had to be laid straight behind the cabinet.

Cable and Socket Harmony

The RCA connectors sometimes gave rise to criticism: The Oehlbach plug fit so tightly that it gave our test team withdrawal anxiety. The locking collars on some of the cables, including the Kimber, were rough on lower quality sockets and were also tricky to use. With those plugs, multiple attempts were sometimes necessary before a reliable ground contact was made. The Gold Cable, Mogami, Silent Wire, The Chord Company and Van den Hul plugs were preferred.

Also worth noting is that the non-shielded Kimber and the Van den Hul with its relatively high shield resistance were somewhat sensitive to external noise sources such as fluorescent or energy saving lamps. For both, we therefore recommend during setup to “test listen” near the speakers - or even better on headphones - paying attention to any induced hum.

Finally, we have a hot tip for you: A drop of Ballistol oil on socket and plug ensures wear-free mating of plugs and also a reliable electrical connection.

Jürgen Schröder ■

Editor Marco Breddin confirming the results from the test rounds in the listening room with a noble headphone system.

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