

## Cartridge-making Dictionary Audio-Technica's guide to cartridge-making terminology

### 33rpm

very often denotes 12" LP Vinyl records (1949-Today), that should be played at a speed of 33 1/3 rpm, rpm stands for Rotation Per Minute.

### 45rpm

45rpm very often denotes 7" Vinyl records, (1949-Today) that should be played at a speed of 45rpm, rpm stands for Rotation Per Minute.

### 78rpm

78rpm very often denotes 10" Shellac SP Gramophone records (1925-1950) that should be played at a speed of 78rpm, rpm stands for Rotation Per Minute.

### Anti-skating

When the record is in play, the friction between the stylus in the groove of the record and the length of the arm (the distance between the tip and the arm bearing) creates a force that pushes the cartridge toward the center of the disk. Anti-skating creates a force that pulls the arm towards the outer edge of the disc to compensate it. Because records don't have a constant amplitude, a static compensation will never totally cure the problem. It is a matter of balance. Badly set anti-skating will produce channel balance and distortion issues. When the anti-skating is set too high, the left channel will distort during loud passages, while on the other side if it's too low, the right channel will distort. Also the amount of anti-skating depends on the shape of the tip. Conical stylus tends to require more anti-skating (due to the amount of friction generated by their shape) than more complex shapes (Line contact or Micro linear).

### Azimuth (see also Tilt)

For magnetic tape drives, azimuth refers to the angle between the tape head and magnetic tape. For phono cartridges, Azimuth is the angle between the surface of the record and the vertical axis of the cartridge.

Note the difference between cartridge removable head shells: some models such as the "Technihard series" (page 30) feature an "azimuth" adjustment. This feature is particularly useful when it is not provided by the tone arm itself.

### Bonded diamond

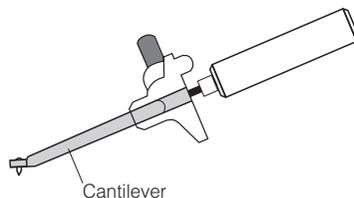


Bonded diamond refers to a stylus where the diamond tip is glued on a metal shank that is itself glued into the hole of the cantilever. This construction may increase the mass of the overall tip and affect transient reproduction compared with nude styli that are preferred and used on higher-priced models.

### Boron (boron cantilever)

Boron is a chemical element from the metalloid family, extracted from Borax and Kernite. Its atomic number is 5. Boron is used for high-end cantilevers due to its lightweight and high-rigidity properties. It reaches a score of 9.5 on the Mohs hardness scale (for reference Diamond scores 10 and Aluminium 3).

### Cantilever (stylus cantilever)



Styli are principally made of three components: Stylus Tip, Stylus Cantilever, and Stylus Suspension.

The cantilever is a tiny suspended "arm" (solid or pipe) that holds the Diamond Tip on one end and transfers the vibrations to the other end where the Magnets (in case of MM cartridges) or the Coils (in case of MC cartridges) are housed.

Different materials are used to make a cantilever: Aluminium, Saphyr, Beryllium, boron... The lighter and stiffer being the best.

### Cartridge (Phono Magnetic Cartridge)

The phono cartridge is the transducer used for the playback of gramophone records.

The phono cartridge converts the mechanical energy (vibrations) from a stylus riding in a record groove into an electrical signal that will be amplified then processed, recorded, or played through a sound system.

### Channel Balance

The channel balance of a cartridge is the ability of the transducer to reproduce left and right channels in the same manner. Channel balance should be part of the cartridge specifications, it expresses the possible output difference in dB from one channel to another. A cartridge with ideal channel balance will playback any mono signal with equal level in both channels. The channel balance will be 0dB. The ratio of the signals between the two channels is specified in dB. Channel imbalance can result in several factors independent from the cartridge itself: mechanical factors include incorrect azimuth settings, misalignment of the tonearm and/or of the cartridge on the headshell, and/or improper anti-skating adjustment. Other Channel imbalance issues, independent from the cartridge or the turntable, could include mismatched cables, electronic elements such as stereo preamplifiers, speaker system, speaker positioning and/or room acoustics.

### Channel Separation

The channel separation of a cartridge is the ability of the transducer to deliver only signal on the left channel of the cartridge, and nothing on the right channel when there is only signal on the left channel groove, and vice versa. Channel separation is frequency dependent. Audio-Technica indicate in the specifications the Channel separation, specified at 1kHz. For high-end cartridges, Audio-Technica provides channel separation curves, showing the separation in dB from 20Hz to 20,000Hz. A high channel separation provides a better stereo image.

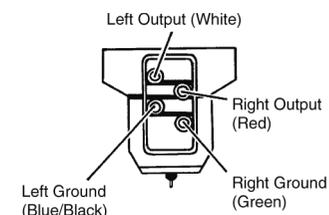
### Compliance

Compliance is the inverse of stiffness. Every cartridge works as a suspension, a high compliance cartridge will be suited for a low mass tonearm and a low compliance (stiffer) cartridge will be suited for a high mass tonearm.

There is not a perfect compliance number, the cartridge compliance together with the effective mass of the tonearm/cartridge combination determine the tonearm's fundamental resonance.

For optimal results the frequency should be maintained between 9-13Hz.

### Connecting (the phono cartridge)



To install a Phono cartridge, connect the four wires of the cartridge headshell to the correct terminals on the back of the cartridge.

The four wires are colour-coded and generally labeled as follows :

Left Channel: **White**  
Left Channel Ground: **Blue**  
Right Channel: **Red**  
Right Channel Ground: **Green**

### Conical



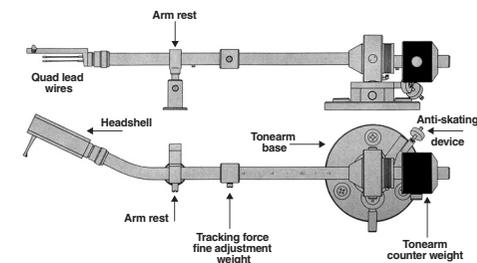
(form factor of the diamond stylus)

Also called spherical, because of the shape of the tip of the cone.

Conical shaped stylus are simple to produce, therefore it becomes the most popular when economy is a factor.

### Counterweight

(Tonearm Counterweight)



### Dual Moving Magnet cartridge

Audio-Technica's patented Vertical Dual Magnet phono cartridge, unlike conventional cartridges, use the 90° V-Shape of the cutter head. The standard cutter head (used to record the vinyl master) uses two transducer coils, mounted perpendicular to each other at 45° from horizontal, to cut the channel: one in each wall of the 90° record groove.

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This way, the cartridge achieves accurate tracking, excellent channel separation, high definition of the stereo image and extreme clarity over the entire audio spectrum.

### Elliptical



(form factor of the diamond stylus)  
An Elliptical stylus is produced starting from a Conical Stylus, then two cuts are made in order to make the vertical contact

longer and the front to back contact narrower.

The elliptical tip follows the groove modulation with more precision than a conical tip, improving frequency response, phase response, and lowering distortion, specifically in the inner turns of the record.

### Frequency Response

Frequency response is the quantitative measure of the output spectrum of the cartridge in response to the stimulus of the record groove modulation.

It is a measure of the magnitude for the output as a function of frequency; typically measured in decibels (dB). In the case of cartridge measurement, the input signal will be a constant-amplitude pure tone through the bandwidth provided by a reference record.

### Impedance

The impedance is a measure of the total opposition that a circuit presents to alternate electric current. The output impedance of an electronic device is the impedance of its internal circuit "seen" by any device connected to its output. The input impedance of an electronic device is the impedance "seen" by any source connected at its input.

Input impedance of the phono preamplifier and output impedance of the cartridge should be properly matched to achieve optimal sound. An impedance mismatch will work as a filter and degrade the sound making it dull or harsh depending on the setup. A general rule of thumb is that the input impedance of your phono preamp (also referred to as the load impedance of your cartridge) should be 10 times the output impedance of your cartridge (also called the source impedance).

### Line contact



(form factor of specific stylus diamonds) Audio-Technica uses Line Contact shape stylus on several high-end cartridge styli.

The tip of the diamond is such that it allows a contact surface between 50 and 75  $\mu\text{m}^2$ . The shape is "similar" to other diamond tips known as Shibata.

### Load

When connected to a phono preamp, the cartridge forms a RLC (Resistor, Inductor, Capacitor) circuit which acts as a resonant filter emphasizing certain frequencies while reducing others. In order to achieve to most linear frequency response, manufacturers specify several load values (load capacitance, load impedance and so on). By following these specifications for the choice of the phono stage, one can achieve the best sonic results.

### LP Record

LP stands for Long Play or 33 rpm microgroove vinyl record format. Introduced by Columbia Records in 1948, it was adopted in the mid-fifties as a new standard by the entire record industry. It became stereophonic in the mid 60's and is still the standard format of vinyl albums today.

**Magnetic cartridge** (see cartridge)

### MC phono input

MC stands for Moving Coil. A Phono Input on a preamplifier or Amplifier mentioning MC means that the characteristics of the preamplifier input stage, in terms of Input impedance, Gain and de-emphasis equalisation are such that it will allow you to use a Moving Coil Phono Cartridge by plugging it into this input.

**Micro linear** (form factor of a stylus diamond, see MicroLine™)

A specific shape of a diamond stylus, Micro linear refers to a particular "ridge shape" stylus. An Audio-Technica trademark, Micro linear styli are known as MicroLine™.

### MicroLine™



Audio-Technica Trademark which denotes the Micro linear "ridge" shape stylus.

The tip of the diamond is such

that it allows a contact surface of around 115  $\mu\text{m}^2$ . The shape is "similar" to other diamond tips such as SAS, Dynavector or Namiki.

The MicroLine™ diamond is different from Line Contact diamonds, also featured on high-end styli. Line Contact tips are also known as "Shibata", providing a contact surface between 50 and 75  $\mu\text{m}^2$ .

### MM input

MM stands for Moving Magnet: an MM input denotes the input stage of a preamplifier is able to handle the signal of a Moving magnet phono cartridge and the MM input also has an input impedance suitable for the output impedance of MM cartridges.

### Monaural

Monophonic sound reproduction (often called mono) is single-channel audio program material or single channel audio reproduction. Monaural recording on vinyl has been replaced by stereo sound during the mid 60's. 78rpm records and Vinyl records from 1952 to 1960 are Monaural. Stereo sound on vinyl records was introduced in 1958.

### Moving Coil cartridges

The MC design is a tiny electromagnetic generator, but as opposed to MM design, the 2 coils are attached to the stylus (the moving part), and move within the field of a fixed permanent magnet. The coils are much smaller than MM cartridge coils and made from very thin copper wire. This result in a low impedance, low output signal but on the other hand it is also very lightweight allowing for a better response and a more detailed reproduction. Moving coil cartridges are extremely small precision devices and as a consequence they are considerably more expensive, but are preferred by audiophiles due to measurable and subjectively better performance.

### Moving Magnet cartridges

The MM design is a tiny electromagnetic generator, but as opposed to the MC (moving coil) design the stylus cantilever carries a pair of small permanent magnets. Those magnets are positioned between two sets of fixed coils forming the tiny electromagnetic generator.

As magnet vibrates in response to the stylus following the record groove, it induces a tiny current in the coils.

### Mu-metal (shielding)

Mu-metal is a range of nickel-iron alloys that are notable for their high magnetic permeability. The high permeability makes mu-metal useful for shielding against static or magnetic fields.

Mu-metal is frequently used to protect low signal transformers such as the ones found on microphone preamplifier input stages or on the Cartridge step-up transformers used with MC cartridges.

Several models of Audio-Technica cartridges use Mu-metal shielding between the left and right sections of the cartridge in order to improve channel separation.

### Neodymium

Neodymium is used as a component in the alloys used to make high-strength, powerful permanent magnets (neodymium magnets). These magnets are widely used throughout the audio industry in products such as microphones, professional loudspeakers, or in-ear headphones, where low magnet mass or volume, and strong magnetic fields, are required.

### Nude Shank diamond



Nude



Bonded

Nude diamond refers to a stylus when the diamond glued into the hole of the cantilever is made out of one single piece of diamond.

This construction as opposed to Bonded shank (jointed) improves the mass of the overall tip and, because the vibrating signal does not have to transfer through two different materials, provides the best possible transient

reproduction. Nude styli, although expensive to produce, are preferred and used on the higher priced models.

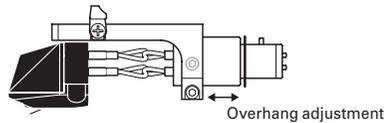
### Output Voltage (of a cartridge)

Amplitude in mV of the electrical signal delivered by the cartridge for a given standard program material of the record groove. Knowing the Output voltage is an important factor: it will inform of the characteristic of the Phono input needed in

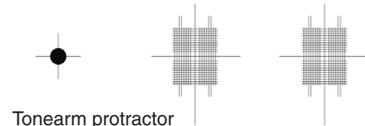
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order to accommodate a given cartridge. Output voltages may vary from under 0.1mV for the least efficient Moving Coil models on the market, up to 5mV for very efficient Moving Magnet cartridges. Such differences of more than 30dB shows that when selecting a cartridge, the selection of the associated preamplifier, with or without step-up transformer, is essential.

**Overhang** (Cartridge overhang adjustment)



In the case of cartridges mounted on a removable headshell, it could be necessary to adjust the cartridge by several millimeters in order for the stylus to be properly aligned with the tangent of the groove. Older tonearms provide adjustment on their bases in order to perform a proper setting using a tonearm protractor alignment system. Most modern tonearms do not provide this feature. In such a case, it is important to be able to adapt the distance between contact point of the stylus and axis of the tonearms with the Overhang adjustment provided by the cartridge headshell.



Tonearm protractor

### Para-toroidal coil

Para-toroidal coils are used on high-end Moving Magnet Audio-Technica cartridges, providing better channel separation, channel balance and improved transient response. Para-toroidal inductors are passive electronic components, widely used for transformer construction. The inductor with a closed-loop core can have a higher magnetic field and thus higher inductance and Q factor than similarly constructed coils with a straight core. The advantage of the toroidal shape is that due to its symmetry, the amount of magnetic flux that escapes outside of the core (leakage flux) is minimum; therefore it radiates less electromagnetic interference to nearby circuits or equipment.

### Phono Preamp

Denotes a preamplifier with an input or a series of inputs capable of handling the output from a Phono cartridge. As opposed to a "standard" line input preamp such as a Microphone input preamplifier, the Phono Preamplifier will provide the necessary gain, Input impedance matching to the output impedance of the cartridges, and the de-emphasis equalisation needed to support the signal originated from the phono cartridge playing a record. In the case of a Vinyl record, the equalisation will usually be RIAA.

**Phono Cartridge** (see Cartridge)

### Phono input

Denotes the pair of input connectors (L&R) of the Phono Preamp.

### Pole Piece

The pole piece is a structure composed of material of a high magnetic permeability that serves to direct the magnetic field produced by the magnet. A pole piece attaches to and, in a sense, extends a pole of the magnet, hence the name.

### Radius (stylus Radius)

The radius of a stylus is the distance (R) in either mil (thousandth of an inch) or  $\mu\text{m}$  (micro,  $10^{-6}$ , of a meter). The conical stylus has a unique Radius which varies from 0.6 to 0.7 mil for Vinyl records. (2, 2.5, 3, or 3.5mil for shellac records). The elliptical stylus has two radii, R1 and R2, for the front and side. Standard elliptical Stylis are around 0.3 x 0.7 mil. Due to the complexity of line contact and MicroLine™ stylis, their radius value is not always an accurate description of their shape and size.

### Replacement Stylus

Stylus assembly of Moving Magnet cartridges are field replaceable. When the diamond is worn out, (between 600 and 1000 hours) or if the cantilever becomes damaged, the stylus assembly needs to be replace. The Stylus assembly represents between 60% to 80% of the cost of a complete cartridge (depending on the nature of the diamond tip). It makes sense, not only for economic reasons but also to avoid work on

the cartridge wiring or mechanical position, to replace only the Stylus assembly instead of the complete cartridge.

### RIAA

RIAA stands for: Recording Industry Association of America (RIAA), the trade organization that represents the recording industry in the United States. Early RIAA standards included the RIAA equalization curve, the format of the stereophonic record groove and the dimensions of records.

### RIAA equalization

is a specification for the recording and playback of phonograph records. The purpose of the equalization is to permit greater recording times, improve sound quality, and to reduce the groove damage that would otherwise arise during playback. RIAA equalization is a form of pre-emphasis on recording and de-emphasis on playback. A recording is made with the low frequencies reduced and the high frequencies boosted, and on playback the opposite occurs.

### RIAA input

(Also known as Phono input)  
Input of a preamplifier section providing the de-emphasis equalization needed to support the signal originating from a phono cartridge playing a vinyl record. (Note: Most 78rpm shellac records produced after 1942 can be played with RIAA equalization, nevertheless we recommend you check the nature of the pre-emphasis used by the record company.)

### Round Shank



Specifically the shape of the shank where the tip is fitted. Round shank is generally used for shapes that require no or minimal orientation (round, conical elliptical)

### Shellac record

Shellac records are also described as 78rpm records or SP (Short Play)

### SP record

 (see Shellac record)

SP stands for Short Play denoting 78 rpm Shellac records, as opposed to LP (Long Play) denoting 33 1/3 rpm microgroove vinyl records.

**Spherical** (diamond, see conical)

### Square Shank



Square shank stylis cost more than round shank to make but mounting them in laser cut holes in the cantilever locks them precisely in correct alignment with the record groove. This is the reason why they are used for shapes that need a precise orientation (Line Contact, MicroLine™).

### Step-up Transformer

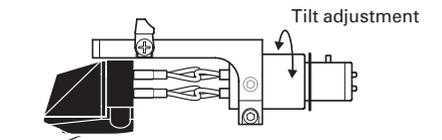
An MC cartridge has both a low output voltage (generally below 1mV) and a low output impedance compared to a MM cartridge. The role of the step-up transformer is to raise the output voltage while, at the same time, match the required impedance between your cartridge and the phono preamplifier.

### Stylus Holder (Stylus Assembly)

The plastic part of an interchangeable stylus that holds the cantilever and the vibrating part, both forming the Stylus assembly.

On Moving magnet cartridges, the removable stylus assembly is held in place on the cartridge casing.

**Tilt** (see also Azimuth)



Tilt is the angle between the surface of the record and the vertical axis of the cartridge. This angle should be 90° in order to insure optimal channel balance.

### Tracking Force

To play back a vinyl disc, the stylus must make good contact with the walls of the record groove. Excessive down force (tracking force or tracking weight) will both wear and not

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guarantee that the stylus will perfectly follow the record groove.

Audio-Technica specifies the tracking force, for each cartridge, as a range of recommended values in grams.

A cartridge given insufficient tracking force is more likely to cause damage to the groove wall than one whose tracking weight is set at the high-end of the recommended range. The cartridge could lose contact with the groove wall, or "jump", causing damage to the record as it bounces trying to regain contact.

**Tracking weight** (see Tracking force)

### Transient Response

The transient response is the behaviour of a system when a signal is changing from one value to a specified higher value.

Rise time (the time required for the signal to change) and Overshoot are among the most important parameters entering under the generic definition, Transient response.

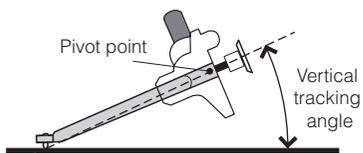
A transducer having a good transient response will result in perceiving that the music material is sharp, with fast accelerations, capable of reproducing accurately and in a realistic manner the fastest impulses of musical instruments.

On a record, the signal is present in the groove, the cartridge is transforming the mechanical groove of the record into an electrical current, and the transient response of the cartridge will essentially respond to fast changing sound waves present into the groove.

Under Transient response, the capacity of the moving parts such as cantilever/stylus/tension spring assembly to be controlled and not to produce parasitic oscillations is also part of the transient response quality. The capacity of the system after changing to revert to its equilibrium is also important.

### Vertical Tracking Angle

Vertical Tracking Angle is the angle between the record surface and the axis "cantilever-pivot-point" to "stylus-contact-area".



**Vinyl** (see also LP record)

Vinyl for most people denotes a 12 inch, 33rpm, microgroove LP record.

The word Vinyl comes from the chemical form of the material used to produce LP records: vinyl chloride.

An important industrial application of this

molecule is PVC (Poly Vinyl Chloride), the plastic commonly known as vinyl.

Vinyl was used for the first time to produce records by Columbia in 1946. During the early 50's the Vinyl record replaced the 78 rpm Shellac SP record as the standard.

**VM™** (see Dual Magnet cartridge)

## Understanding the sizes and shape of Audio-Technica stylus tips and the contact area in the record groove

Stylus sizes Stylus shape	0,6mil Conical stylus	0,2 x 0,7mil Elliptical stylus	0,3 x 0,7 mil Elliptical stylus	Line Contact stylus	Shibata	MicroLine™ stylus
Stylus front view						
Stylus horizontal cross-section						
Audio-Technica moving coil cartridges	AT33MONO AT-MONO3/LP	AT-F7	AT33EV	AT-ART9 AT-OC9/III AT-ART7	AT33sa	AT-OC9ML/II AT33PTG/II
Audio-Technica moving magnet cartridges	AT5V AT91		AT120Eb AT100E - AT95E			AT150MLX AT440MLb
Audio-Technica moving magnet P-mount cartridges	AT3482P AT300P		AT311EP			
Dimensions (see horizontal cross section)	R=0,6mil = 15,25µm	R=0,7mil = 17,8µm r=0,2mil = 5,08µm	R=0,7mil = 17,8µm r=0,3mil = 7,6µm	R=40µm r=7µm	R=75µm r=5µm	R=75µm r=2,5µm
Contact surface on record groove (stylus side view)						
Approximative contact dimensions ratio	D1/D2=1	D1/D2=1,85	D1/D2=1,60	D1/D2=2,25	D1/D2=3	D1/D2=6

<sup>(1)</sup> D2 represents the contact dimension at the horizontal plane while D1 shows the contact dimension at the vertical plane. These two dimensions indicate the contact area between the record groove walls and the stylus tip. D2 must be as small as possible to track small groove variations (high frequency). The total contact area should be as large as possible to minimize record wear and maximize accurate reproduction. The larger the area, the smaller the pressure from the cartridge on the record; as opposed to the smaller the area, the more pressure is applied on a specific point of the groove, leading to record wear.

We can see from the above table that the Line Contact and Micro linear shapes offer a smaller horizontal contact area leading to superior precision and high frequency transcription, while offering a larger contact area than conical and elliptical styli due to taller vertical contact area minimizing record wear.