

**What is bias force and how is it generated:**

In pivoted tonearms with optimal tangential geometry the tracking error is below 2 deg. When the needle is in the groove of a rotating disc, friction creates tangential pulling force along the groove which also creates a side force pulling the needle and tube inwards towards the centre of the record.

That means that there is higher pressure on the wall of the inner groove than on the outer groove. Theoretically we experience tracking distortion first in the right channel which is the outer wall.

**Basic solutions on tonearms:**

Most pivoted tonearms have a built in antiskating mechanism or bias compensation to compensate the side force pulling the tube inwards. A higher VTF ( Vertical Tracking Force) creates bigger side force-bias and therefore needs bigger compensation. In tonearm manuals you will read that bias compensation is related to the cartridge's VTF by same number expressed in grams.

In most situations this is the safest way to get bias compensation reasonably correct providing that the tonearm's bearings are good and the turntable horizontally levelled.

**Advanced bias set:**

As well as following the manual, we can try to use various bias set up suggestions, from using a blank record –wrong, to zero bias – wrong, to using test records with various tracking grooves. Optimally you can use test track records and set up bias for minimal distortions by ear or using an oscilloscope. Of course there are various test records with different results. You can also use WallySkater and follow their instructions for optimal bias set up.

In reality you will not hear tracking distortion in music due to wrong bias set up but it is most likely caused by other reasons such as a worn cartridge, poor bearings, poor general set up, dirt and worn and damaged record, etc.

Bias set up is an average value. In reality it will be too strong or too weak for some parts of the record due to a number of reasons. Record warps and record eccentricity changes VTF, thus bias, as the whole tonearm tube travels in and out or up and down in the record grooves.

Too weak bias means that there might be damage to the right channel when the needle loses groove contact. Too strong bias means that the left channel groove and left side of the needle might have more wear.

Be aware that mis tracking causes more damage to the record. Needles are easier to replace than the records.

**How to be sure that bias set up is optimal:**

Follow the tonearm's manual and be sure that your turntable is **levelled horizontally in all directions**.

If you wish you can control bias set up by using WallySkator or test records.

**But:**

But there is a problem. If the turntable is not levelled horizontally the tonearm tube will swing in one or another direction increasing or decreasing bias force.

We do need to keep the vertical axis of the horizontal bearing truly vertical. Heavy mass tonearms with high quality bearings would be the most sensitive to levelling errors. Unipivot tonearms are less sensitive to levelling.

How do we know how much precision in turntable levelling is required or more precisely how much the tonearm must be horizontally levelled to keep a correct bias set up?

**Bias testing:**

We have run tests in our lab and have come to some conclusions, details of which you can see elsewhere. See links below for more information.

We compared our Safir 9 tonearm and cartridge with no wire loop and no bias mechanism, versus the standard Safire 9 and cartridge tonearm to see how much horizontal levelling affects the bias force. We tested them in the inner groove position and measured bias force using WallySkator Pro.

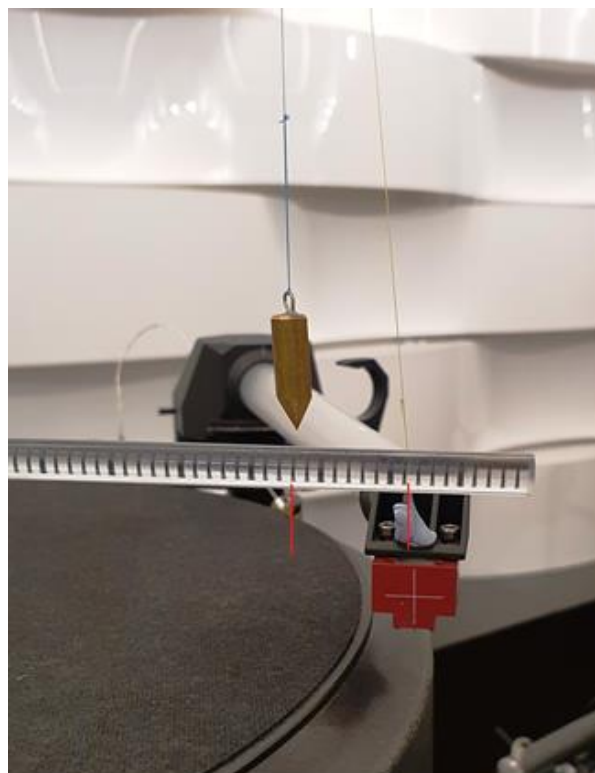
**Tonearm with no wires and no bias mechanism:** VTF of 2 grams was horizontally levelled by the use of precise spirit levels and a reading on WallySkator Pro was less than 1 %. That means that the vertical axis of the horizontal bearing was truly vertical and no other forces were acting on tube movement.

**Tonearm with wire loop and bias on minimum:** A VTF of 2 grams was again levelled and the reading on WallySkator Pro was around 1-2 %. This indicated that the wire loop and minimal bias had a small effect on bias force.

**Tonearm with wire loop and bias set per manual:** VTF and bias for 2 grams was levelled and the reading on WallySkator Pro was in the range of 11 % as suggested in the WallySkator manual. This proved that when the tonearm is properly horizontally levelled, bias set up as per Safir 9 manual was optimal.



WallySkator Pro showing 11 % bias-inner groove



WallySkator Pro showing 8 % bias-outer groove

#### **How much effect has horizontal levelling on bias force:**

On the standard Safir 9 tonearm set up with a VTF 2 of grams, which was precisely levelled, we set up minimal bias and the reading was 1-2 % on WallySkator pro.

We tilted the horizontal level in a left-right direction only. When we reached the required 10-12 % on WallySkator Pro we measured the horizontal level. It was off for 0,5 deg indicating that this error gives the same reading range as bias.

Then we add bias as per manual for 2 grams and we got reading on WallySkator Pro 20-22 %.

#### **CONCLUSION:**

**Horizontal precise levelling of the tonearm (not necessary turntable) is mandatory in all directions.** As we found an error of 0,5 deg in one direction can give side force to the tube equivalent of the required bias force, thus making bias compensation too strong and wrong.

**We suggest the levelling error to be kept below 0.2 deg (about 3 mm on 1000 mm length).** This will give a reading below 3-4 % on WallySkator Pro which is an acceptable error.

We got acceptable results on Safir 9 tonearm horizontal levelling using several sensitive round spirit levels, so be sure to use enough sensitive spirit levels.

Before you conclude that bias is too strong, do check and adjust tonearm horizontal levelling in all directions.

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