Hybrid Wire Scales for Pianos

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Terms to know include: Inharmonicity, (IH); Unison Coupling, (UC); Longitudinal mode, (L-Mode); Transverse mode, (T-Mode); Breakpoint, (BP); Elastic limit, (EL); Young’s Modulus of Elasticity, (YM).

This class is a presentation and demonstration of how to improve the musical utility of a piano by placing Pure Sound stainless steel alloy and Paulello high-carbon steel piano wire in the portions of a piano scale that are at a low, BP percent.

Please note; I am not compensated in any way for mentioning these products.

The standard for wire scale modification practice since the late 1970s has been to convert low BP plain tri-chord unisons to high BP wound bi-chord unisons. This is usually done with the goal of reducing the IH of the low BP plain strings at the scale break between the treble and bass bridges.

I have done a number of plain tri-chord to wound bi-chord conversions and while the volume, tunability, and tuning stability are improved-the musical utility is often not improved or even worsened.

I have found that there are two main reasons why this conversion to bichord from trichord reduces musical utility. One is that a significant part of the proper tonal character of a piano comes from the full effect of three unison strings coupling together in phase and frequency due to the influence of the piano soundboard/bridge. It is very difficult to make great tone with bichord unisons higher in the compass than about note 24. Our ears “require” the more complex sound of trichord coupling. The other is that L-Mode is at least as significant as IH in our perception of piano tone quality.

The plain wire types I have used to improve scale breaks in pianos are Pure Sound stainless steel alloy and type O Stephen Paulello piano wire. Paulello makes a type one and two wires which are even softer with further reduced break strength.

BP percent can be determined by calculating the tension of a given string and dividing that by the BP for that diameter of modern piano wire.

Tension formula for determining pounds of tension from inch lengths and diameter is as follows; (FxLxD) squared, times 2.303 x 10 to the -3 exponent, equals T in pounds. [F equals frequency. L equals speaking length. D equals string diameter. (Length and Diameters are in inches).]

Low BP portions of a piano scale are between 20% and 45%.

Desirable BP for great piano scales is from 45% to 62%.

All piano wire (of the same type) breaks at the same pitch. What this means is that

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speaking length is the important factor for BP in plain wire and for wound strings, the core wire diameter is also a factor. In fact the smaller sizes of plain wire are very slightly stronger, but for the purposes of this work, this can be ignored.

The EL of modern piano wire is at 70% BP. To have a robust piano scale there needs to be a margin of safety for the wire. Best practice is to not exceed 65% BP.

The BP across the compass of a typical concert grand scale starts at nearly 60% at note 88, descending gradually to around 43% at note 21. Then note 20, the first wound string, at around 60%, descending to the lowest bi-chord at around 45%. Then the highest monochord is around 60%, descending to around 45% at the lowest A.

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| --- | --- | --- | --- | --- | --- |
| Gauge  12  12.5  13  13.5  14  14.5  15  15.5  16  16.5  17  17.5  18  18.5  19  19.5 | Dia. Inches  .029  .030  .031  .032  .033  .034  .035  .036  .037  .038  .039  .040  .041  .042  .043  .044 | BP  247-257  262-272  273-285  286-299  303-318  319-332  333-348  351-368  366-382  380-396  398-416  416-435  433-452  451-472  470-491  490-511  Pounds  Tension | Gauge  20  20.5  21  21.5  22  22.5  23  24  25  26  27  28  29  30 | Dia. Inches  .045  .046  .047  .048  .049  .050  .051  .055  .059  .063  .067  .071  .075  .080 | BP  509-531  529-554  550-578  570-598  590-620  610-641  635-667  734  839  951  1,025  1,155  1,270  1,425  Pounds Tension |

In calculating BP% I use the lowest BP from the ranges given in the chart. For example diameter .042 BP is 451 pounds tension. Strained at 140 pounds tension, this wire is at 31% BP.

The BP protocol I follow in creating a hybrid wire scale for the plain strings is: at 35% BP or less, use stainless alloy wire of similar diameter to the original.

When the BP is between 33% and 45%: I use Paulello type O of similar diameter to the original.

Some scales increase the wire diameter every two to four notes in the low BP area. I Page three of five

don’t see any advantage to duplicating that. No piano needs 21 gauge wire at note 24.

It is my opinion that the smoother, warmer sound heard when Pure Sound and type O Paulello wire is used in place of high BP modern piano wire is mostly the result of reduced production and amplitude of L-Modes. .

The PTG foundation should hire a testing lab to test selected sizes of all piano wire currently produced for BP, EL, L-Mode, YM, and size tolerances. This would give us more assurances regarding the limits of these hybrid wire protocols.

We have many new choices in designing a hybrid wire scale than we have ever had before. The new types of wire choices that I am aware of include:

Paulello type M: which is a fully modern wire.

Paulello type O: which I treat as being about 10% less BP than modern wire.

Paulello type I: which I treat as being about 20% less BP than modern wire.

Paulello type II: which I treat as being about 30% less BP than modern wire.

All three Paulello wire is high-carbon steel and can be had with nickel plating.

Pure Sound stainless alloy: which I treat as being about 25% less BP than modern wire.

Paulello also makes nickel-plated iron wrapping wire and Mapes makes both copper and stainless steel alloy wrapped strings. Mapes will use Paulello type O for wound string cores but you must provide the core wire.

The Pure Sound stainless wire is significantly more fragile than high-carbon steel wire. Extra care must be used when installing it so as to not bend it any more than is needed. Do not raise it above pitch to make it settle quicker. It stabilizes very quickly at pitch. I

would not use it in pianos that have agraffes with steel inserts in them. I would not use it for wound string core wires.

I am very excited about all the wire choices we have today to solve tonal problems in pianos that we service and rebuild. Many new or newer pianos with clanging L-Modes in the tenor could have just a few consecutive notes restrung with hybrid wire at a very low service cost. Clanging wound scales and ill-defined low notes could also be redone in new or newer pianos with modest additional service cost.

The worst (to me anyway), L-modes are usually in the highest monochords.

The protocol for wound strings is to use type O core for the lowest bi-chord and the first two to five monochords. Make the lowest bi-chord string the same wrap as the note above, but switch to type O core of the same size. Load the highest monochord to about 58%BP and drop BP in graduated way as you descend in the scale. When you reach the largest diameters of wrap possible, and BP has dropped to around 47%, use type O cores Page four of five

and continue with BP’s of 45%.

The first piano I placed a hybrid wire scale in was a 6’4” Steinway A. This was done in 2006. Notes 26, 27, 28, & 29 use Pure Sound stainless steel alloy plain tri-chords. Notes 30, 31, 32 & 34 are Paulello type O high-carbon plain tri-chords. The lowest bi-chord has Paulello type O core and the remaining cores and plain strings are Mapes International Gold wire. The piano has been played about two hours a day in the ten years since I rebuilt it. No sign of any problems. No strings have broken anywhere. She wore the hammers out by 2017 and they were about half gone when I did the rebuilding work and she began to play the piano.

This has given me greater confidence in the durability of the Pure Sound wire. I still don’t think it is practical for a manufacturer to use Pure Sound in low BP notes, but if a technician is very careful and installs the wire without any extra bending or sharp tuning it appears to be strong enough for many pianists.

Unfortunately Pure Sound wire is no longer available, so Paulello Type O is the closest match.

A few of the Hybrid Wire Scales I have done are to: Steinway model M, O, big A, and B. Baldwin M, R, and SD-6. Mason & Hamlin BB. Chickering model 121 and 501.

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