ELASTICITY OF VIOLIN STRINGS

Norman C. Pickering
23 Culver Hill
Southampton, N.Y. 11968

In Vol. 44 of the Journal of the Catgut Acoustical Society appeared an article entitled "Physical Properties of Violin Strings". It had been my intention to include in the data presented there information about the relationship between tension and elongation of the strings tested. Such data is a direct indication of the sensitivity to movement of tuning devices, and of immediate practical value to violinists. The lack of these data was pointed out by certain members of CAS, and I assured them that I would provide some as soon as I devised a meaningful approach to obtaining it. This proved to be somewhat more time-consuming than I had anticipated.

The usual way to generate a stress-strain diagram for a linear elastic material is to clamp a predetermined length between jaws in a testing machine. One jaw is equipped with a force-sensitive load cell and is stationary; the other is driven by a traverse mechanism which applies the stretching force, and the displacement is measured. A curve of force vs. displacement is plotted which, for most elastic materials, shows a linear rise followed by a progressively decreasing slope indicating yield of the material. A reversal of the traverse drive plots the return curve, which may show more or less hysteresis, depending on the material and the extent to which it was stressed.

This method proved not to give information of direct benefit to users of violin strings, although it certainly is important to the manufacturers thereof. Musical strings have the following particular conditions of use which indicate that a somewhat different measurement is desired:

1. End connections at the peg and tailpiece may contribute to the actual stretch of a string as used on an instrument.

2. Violin strings are used at a single (open) frequency, and the characteristics at tensions far from normal are not generally of interest to the player.

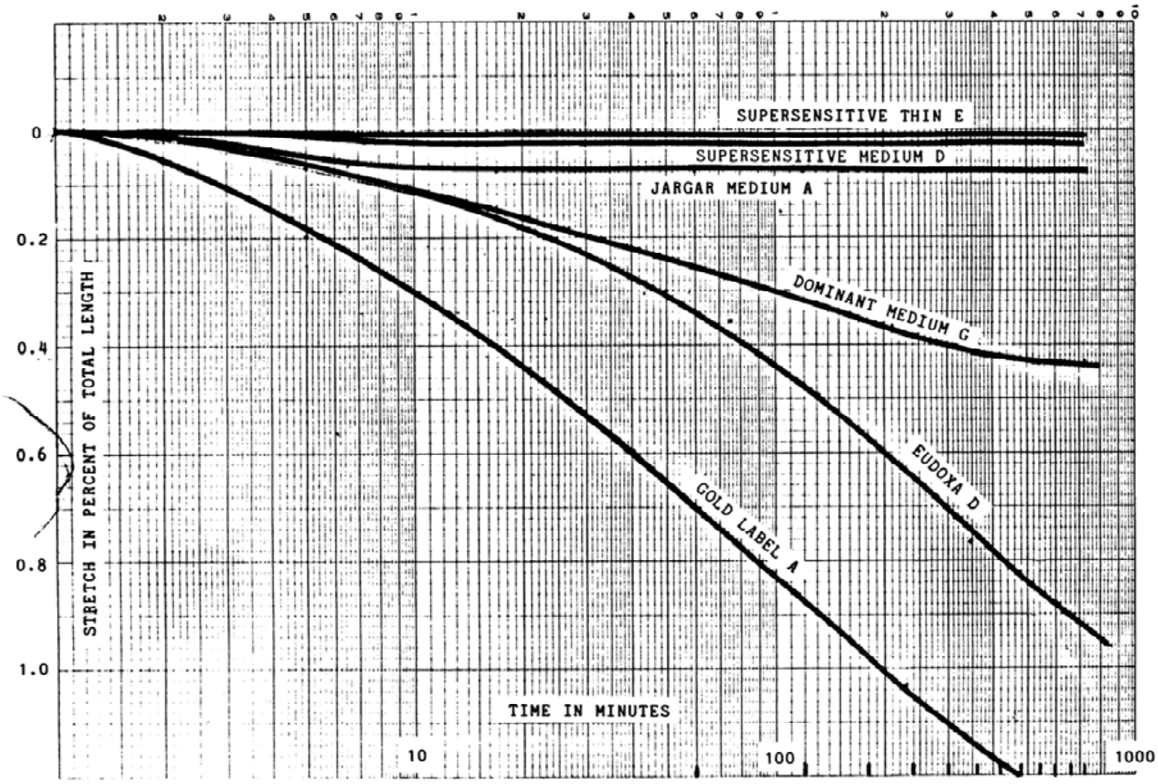
3. There is a very large factor of time dependency for the establishment of final working tension, particularly in gut strings.

4. Humidity has a major effect on tension of gut strings.

The last item in the above list was not addressed in these tests; all were carried out at 60% relative humidity and a temperature of 65 degrees F.

The special machine built for this work consists of a massive bar with a worm-geared capstan at the headstock and an accurate screw at the tailstock. The capstan is 7 mm. in diameter (about the same as a typical violin peg) and the tailstock screw is provided with a ball thrust bearing and a fitting to accept both loop-end and ball-end strings. A dial on the screw can be read easily in increments of .00397 mm. The bridge corresponding to the top nut is 60 mm. from the capstan and the other bridge is 50 mm. from the tail fitting. The bridges are 328 mm. apart but the one near the tail is hinged to obviate sliding of the string through the notch.

Testing is done as follows: The string is fitted as it would be on an instrument, with care taken to have no final overlapping turns on the capstan. The string is brought up to frequency by the capstan mechanism with the dial on the tail screw set at zero. At no time is a string ever tuned above its nominal pitch. The string is excited by very light plucking; the system Q is high enough to permit the optical sensor to give a



usable signal for several seconds, even with string amplitudes not visible to the unaided eye. There is no audible output.

As any string player knows, the frequency of a newly-fitted string drops after initial tuning, and continues to do so for what may be a considerable period of time. As in the real world of music, the strings tested here were retuned frequently at first and at least every hour thereafter until a relatively stable tuning was achieved. An exception to the "every hour" statement was made in the case of the all-gut strings, which required about 48 hours to become reaonably stable; there were periods of several hours during the night when no adjustments were made.

Retuning was done entirely by the precision screw at the tailpiece end, and the change in length recorded as a function of time. Some of that data for certain strings is plotted in Fig. 1 for the initial 12-hour period. The initial "settling" of the string is partially due to conformation of the end connections and, in the case of steel strings, indentation of the bridges which are made of aluminum.

Tuning stability was established by lowering tension momentarily and observing the length when frequency was returned to the nominal value. If the dial of the precision screw returned to its previous indication the string was, for all practical purposes, stabilized. This could take from less than an hour to more than two days.

Elasticity was measured by determining the length change associated with a frequency reduction of exactly one semitone. The tension at the "working" frequency having been carefully measured, it was an easy matter to calculate

TABLE 1.

Elasticity of various violin strings

String Description	Time to Stabilize, Hours	Semitone Shortening, Millimeters	Normal Tension, Newtons	Elasticity Newtons/meter
Jargar medium steel E	1	.205	77.77	24,100
Supersensitive thin E	1	.379	73.76	21,300
Dominant mittel wound E	2	.484	69.53	15,700
Gut E .019" dia. (622 Hz.)	48	1.520	42.79	3070
Jargar medium A	1	.337	56.07	18,150
Pirastro Gold Label A	19	.687	54.15	8600
Dominant mittel A	8	.822	56.25	7470
Dominant stark A	8	.794	56.94	7820
Gut A .030" dia.	48	1.095	47.47	4730
Eudoxa 17-1/4 ga. D (after 1 hr.)		1.087	41.82	4120
(final reading)	12	.837	41.01	5350
Pirastro Gold Label D	14	.718	40.11	6100
Jargar medium D	1	.321	61.73	20,950
Supersensitive med. D	1	.290	57.14	21,500
Dominant mittel D	8	.746	43.72	6400
Dominant silver D	8	.917	43.77	5210
Dominant stark D	8	.822	55.04	7320
Eudoxa G	20	.865	39.18	4940
Pirastro Gold Label G	15	.786	40.78	5670
Dominant mittel G (after 1 hr.)		.754	44.87	6035
(final reading)	12	.686	44.57	6630
Dominant stark G	12	.746	48.58	7100

tension required at the lower semitone. Changes in cross-section were ignored; the change in length between bridges was taken into account, but proved to be almost negligible.

Table 1 lists the measurements made. Many of the strings listed in the earlier cited work were no longer available, and some new ones have been included. Some surprises have emerged; the rather large difference in normal tension between the Dominant Mittel D and Stark D, and, conversely, the almost negligible differences between the Mittel A and the Stark A and between the Mittel D and the silver-wound D. There are still mysteries involved in selecting strings, and it is hoped that information like this will help in the process.