A few remarks about Silk Lines

By Wolfram Schott
2007

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Some time ago this question was asked in a German fly fishing forum: "I have built a copy of an LL Dickerson rod, rated for a 5-weight line. I have tried it but it will not cast a 5-weight properly. Did the Old Masters design their rods for silk lines, and what is the difference?"

While Dickerson could not have rated his rods according to the AFTM system, as it did not yet exist, answering the question turned out to be a somewhat lengthy affair.

Since I had refinished a number of silk lines and collected some information, I sat down and did some compiling of facts. Refinishing silk lines has become a hobby for me, as well as others, so I did some investigating into various possible methods and substances. Little information is available on this topic in modern literature or on the internet, however. One has to study old literature, gathering bits and pieces, and some trial and error is involved in getting a good result.

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Fly lines were originally made from horsehair, specifically from the tail of a stallion, and hair combined with silk and other materials. Twisted, woven or plaited (braided) in various strengths, and tapered towards one end, they usually came in lengths varying between 30 and 40 yards. In the 1870-ies Hardy sold two qualities of fly line. The "Finest Quality London Patent Silk and Hair Lines" in lengths from 20 to 70 yards, and the "Plaited Silk and Hair Line", made in lengths of 20 to 50 yards.

When pure silk lines were braided for the first time, slowly replacing the horsehair, cotton, hemp, linen and composition lines, no standard existed, how thick or heavy these lines had to be. The first producers of such lines made the diameters according to the wire gauges of the time.

The designation of wire by gauge number was in common use earlier than 1735 and the numbering was empirical in the beginning. A wire was drawn through a steel-gauge with several holes of different diameters, making it successively thinner each time. Metal plates with such holes are known as drawplates or dies. There were a number of different gauges: The "Birmingham Gauge", the "Lancashire Gauge", and the "Witworth's Gauge", among others.

The "Imperial British Standard Wire Gauge", which was sanctioned by the British Board of Trade in 1884, was formulated by a J. Latimer Clark. Incidentally, one of its advantages is that it differs from pre-existing gauges scarcely more than they differ among themselves, and it is based on a rational system, the basis being the mil. No. 7/0, the largest size, is 0.500 in. (500 mils or 12.7 mm) in diameter, and the smallest, No. 50, is 0.001 in. (1 mil or about 25 µm) in diameter. Between these extremes the diameter, or thickness, diminishes by 10.557% per step, and the weight diminishes by 20%.

In the US the "American Wire Gauge" was introduced in 1885. It was the first attempt to adopt a geometrical system, and was made by Messrs Brown & Sharpe. They established a regular progression of thirty-nine steps between the English sizes, No. 0000 (460 mils or about 12 mm) and No. 36 (5 mils or about 0.13 mm). Each diameter was multiplied by 0.890526 to give the next lower size. This gauge was only used for non-ferrous metals (like copper). For iron, the empirical "Washburn & Moen Wire Gauge" - also called Steel Wire Gauge - was used since 1830

Other gauges included ones for drill bits, needles, nails, and musical instrument wire (10 different ones!).

The following is from Theophilius South's book, "Fly-Fisher's Textbook" (1841):

> "Salmon Reel Lines. – Now, as to these, they should be from sixty to eighty yards long ... The material, I repeat, should be silk and hair twisted, and the end, for about twelve yards, may taper slightly; though perhaps it is as well to have it of uniform thickness of the 'D' in the third octave of your sister's harp (to measure which, borrow her string gauge), or thinner than a new shilling ... Trout Reel Lines should be of the same material ... and from thirty to fifty yards in length, ... but necessarily much thinner ... they must taper gradually for the last eight or ten yards to the end, where, in substance, they should not exceed the first 'D' on the aforesaid harp gauge, ... while the stouter end should be about equal to the second 'D' "

As said, the first producers of lines made them following the wire gauge numbers to some extent. However, due to the different gauges in use, the first conflicts as to their designation (numbers, diameters), arose.

Silk lines were - and still are - braided in different configurations on machines. There were ones which included copper or brass wire (sinking lines), hollow ones which quickly absorbed water into the hollow core and sunk, those of oval cross section, which developed ribbon-like twisting tendencies, and of square cross section, whose corners wore through rather quickly. Additionally, there were "enamelled" lines with only a thin and hard outer layer of varnish, the largely untreated core of which - often made of cotton - absorbed water quickly and rotted after a short while; lines with many thin or fewer thick threads, with or without a core; and myriad others. They were marketed in their natural colour - "straw" or "amber" - or dyed, usually green or brown. J.P. Traherne was probably the first to construct a true double taper line: His "swelled line", of 40 yards, increased in diameter from the tip to the center of the line, from which point it tapered at the same angle to the rear end.

In the beginning the lines were impregnated (made water repellent) with a wide variety of substances:

> Baltic linseed oil, 1 pint, whitest india-rubber, 3 oz., bees' wax $^1/_4$ oz., gold size, 1 table spoonful
> (A. S. Moffat: The Secrets Of Angling, 1865, p. 24)
>
> One half pint of boiled oil, 3/4 oz. beeswax, 1 $^1/_2$ oz. Burgundy pitch, 1 tablespoonful copal varnish
> (J. H. Keene: The Practical Fisherman, 1881, p. 391)
>
> One tablespoonful boiled oil, beeswax and resin, pieces about the size of a walnut, pulverize the resin and cut wax into thin slices; put them together in a jam-pot and this in boiling water till dissolved
> (J. H. Keene: Fishing Tackle, Its Materials and Manufacture, 1886, p. 56)
>
> ... two thirds boiled linseed oil and one third best coachbody varnish mixed together, and warmed till it will singe a feather
> (H. P. Wells: Fly Rods and Fly Tackle, 1885, p. 50; 1901, p. 73)
>
> ... to keep enamelled lines soft, smooth, and pliable, rub them down with a bunch of curled horsehair and water to clean and smooth them, and this follow, when dry, with pure boiled linseed oil. ... when this has dried, perhaps rub it with a paraffine candle, followed by a dry cloth
> (G. P. Holden: Streamcraft, 1919. p. 38)
>
> Drop material loosely into hot blood of freshly killed sheep, work it thoroughly in with fingers, drop into boiling water for a full minute, hang up in heap till quite dry, smooth, burnish, polish
> (W. S. Jackson: Notes of a Fly Fisher, 1927 and 1933. p. 158)

In 1880 Eaton and Deller, tackle makers, produced the first solid braided silk fly lines with a pure boiled linseed oil dressing applied under pressure by an air-pump, a method derived from experiments carried out by Messrs Deller and Hawkesley and based on suggestions made by F.M. Halford (the so-called Halford-Process). They became the standard by which all other lines were to be judged.

In 1894 Hardy introduced the "Houghton Double-taper Special Dry-fly Line" of 35 yards length. Their best known fly line, the "Corona" first appeared in 1899 and remained in the catalogues until 1969.

In 1908, P.D. Malloch of Perth started to produce the most famous and successful of all silk fishing lines, the "Kingfisher". This line, more than any other, set the standards for manufacture and performance. The name became synonymous with the highest quality silk lines.

The double taper lines were numbered from 1 to 7.
Nr 1, body diameter 0.81 mm/ 0.032 in. was approximately equivalent to an AFTM 3, if a bit lighter
Nr 7, body diameter 1.83 mm/0.072 in. was approximately equivalent to an AFTM 12, if a bit heavier

Numbers 1 to 5 were trout lines (30 yards), and 4 to 7 were salmon lines (40 yards). "Balanced (Forward) Taper" lines were also produced, though a little later, numbers 2 to 4 for trout lines, numbers 4 to 5 for salmon lines.

Confusingly a Kingfisher DT No. 3 had a body diameter of 1.12 mm/0.0441 in., a Kingfisher WF No. 3 one of 1.19 mm/0.0468 in. and a Kingfisher Level No. 3 one of 0.91 mm/0.0358 in.
Other line numbers had comparable differences.

Hardy, though their lines were produced in the same factory (Cumberland), numbered their lines after their own system. Specified were the British Wire Gauge Number, the diameter in decimal inches and the approximate weight of the line. Also a size was designated: from "X Fine I.E.I" to "Heavy I.B.I." for trout lines.

These letters, however, do **not** correspond to the later NAACC-system (see below). For salmon lines numbers 1 (thick) to 6 (thin) were used, also including the diameter and weight details.

Below two tables from a catalogue (1926)

The "CORONA SUPERBA" Trout Fly Lines (35 yards)

Size	British Wire Gauge		= in 1000 of an inch		Approx. Weight
	Points	Centre	Points	Centre	
X Fine I.E.I.	24 1/2	21 1/2	0.021	0.030	- 9 drms.
Fine I.D.I.	24	20 1/2	0.022	0.034	- 13 drms.
Medium I.C.I.	23 1/2	19	0.023	0.040	- 15 drms.
Heavy I.B.I.	23	18	0.024	0.048	1 oz. 3 drms.

"Note.- It is not possible to give the length of rod for which each line is suitable, as rods vary so much in strength. As a general rule Ex. Fine and Fine are suitable for 8 ft. 6 ins. to 10 ft. rods; Medium and Heavy for 10 ft. to 12 ft. rods. Exact weight cannot be guaranteed, as the dressing and silk sometimes vary a little".

The "CORONA" Salmon Fly Lines (42 yards)

Size	British Wire Gauge		= in 1000 of an inch		Approx. Weight	Suitable for
	Points	Centre	Points	Centre		Rods
No.1	18	14	0.048	0.080	4 oz. 3 drms.	17' 9" to 18'
No.2	18	15	0.048	0.072	3 oz. 8 drms.	17' to 17' 6"
No.3	18 1/2	15 1/2	0.044	0.068	3 oz. 0 drms.	16' to 17'
No.4	18 1/2	16	0.044	0.064	2 oz. 10 drms.	15' to 16'
No. 4A	18 1/2	16 1/2	0.044	0.060	2 oz. 4 drms.	No. 3 "Wood"
No.5	20	17	0.036	0.056	2 oz. 1 drms.	14' to 15'
No.6	21	18	0.032	0.048	1 oz. 11 drms.	13' to 14'

No. 4A was a special line for the rod "A.H.E. Wood No. 3" of 12 ft. In later catalogues, when lines were numbered differently, Hardy recommended for this rod a "Corona No. 7 Fine Salmon Line, suitable for rods 13 to 14 ft."

Besides the "CORONA SUPERBA"-Trout there was a "HOUGHTON"-Trout Fly Line:

The "HOUGHTON" Trout Fly Lines (35 yards)

Size	British Wire Gauge		= in 1000 of an inch		Approx. Weight
	Points	Centre	Points	Centre	
X Fine I.E.I.	25	21	0.020	0.032	- 9 drms.
Fine I.D.I.	25	19 1/2	0.020	0.038	- 14 drms.
Medium I.C.I.	25	19	0.020	0.040	1 oz. 3 drms.
Heavy I.B.I.	22 1/2	18	0.026	0.048	1 oz. 6 drms.

The "HOUGHTON" lines, though, and likewise another range of lines, the "TOURNAMENT", had different diameters and thus weights, and additionally different tip calibrations

Three examples:	"Corona Fine I.D.I"	0.56 – 0.86 – 0.56 mm	0.0220 - 0.0338 - 0.0220 in
	"Houghton Fine I.D.I"	0.51 – 0.97 – 0.51 mm	0.0200 - 0.0381 - 0.0200 in
	"Tournament Fine I.D.I."	0.56 – 0.81 – 0.56 mm	0.0220 - 0.0319 - 0.0220 in

Later these lines were numbered from 1 (thin) to 12 (thick). These numbers were not identical with those of other companies, and were also different for "Trout" and "Salmon" lines. For example, the Corona DT Trout (30 yards) was numbered from 1 to 5, and the Corona DT Salmon (40 yards) from 6 to 12. The thickest "Trout", No. 5 had a larger diameter (1.42 mm/0.0559 in) than the thinnest "Salmon", No. 6 (1.22 mm/0.0480 in). For comparison, a Kingfisher DT No. 5 had a diameter of 1.42 mm/0.0559 in, a DT No. 6 one of 1.63 mm/0.0641 in.

The "Kelson Double-tapered Salmon Line" was introduced at the same time as the "Corona" (1899), but was replaced by the more expensive "Corona Salmon Line" in1904. The sizing/comparison of the lines (Kelson versus Corona) was something of a muddle. In the 1900 catalogue the "Kelson" sizes were shown in the following manner:
"... the No. 2 being equal to No. 4, 3 equal to No. 3, 4 equal to 2 and 5 equal to 1. No. 6 being a size finer."

In 1938, after a visit by the American casting legend Marvin Hedge at Hardy's, the company introduced "Tournament" lines of 43 and 53 yards length, respectively, named "Marvin K. Hedge Taper". These lines were manufactured by the "SA Jones Line Company" of Norwich, NY, and stocked in 11 sizes, numbers 10, 12, 14, 16, 18, 20, 22, 26, 70, 75, 80, from "Fly Weight" to "Heavyweight Distance Tournament". They were only catalogued for one year, as the outbreak of WW II precluded any further importation from the United States.

In 1969 Hardy stopped selling silk lines

Farlow, too, had its own system of designating their range of "Halford Double Tapered Fly Lines": "Trout" (30 yards), numbered from 1 (thin) to 5 (thick), "Salmon" (40 yards) from 4 (thin) to 7 (thick).

The following recommendations were given in catalogues:

Sizes	Trout (Length 30 yards)	Sizes	Salmon (Length 40 yards)
1	Suitable up to 7 ½ ft. rods	4	Suitable up to 12 ft. rods
2	Suitable up to 8 ½ ft. rods	5	Suitable up to 13 ½ ft. rods
3	Suitable up to 9 ½ ft. rods	6	Suitable up to 15 ft. rods
4	Suitable up to 10 ½ ft. rods	7	Made only to order
5	Suitable up to 11 ft. rods		

Another range, the "Cobra Balanced Tapered Trout Line" (42 yards) was only described as: "Fine", "Medium", "Stout" and "Extra Stout", whereas the "Heron Double Tapered Fly Lines" carried the numbers 1 to 4 for Trout" (30 yards) and 4 to 7 for "Salmon" (42 yards), a descriptive size (Extra Fine to Stout), the Wire Gauge Numbers and the diameters in decimal inches. A recommendation for suitable rods was also included.

The "HERON" Double Tapered Waterproof Fly Lines

Double Taper Trout, 30 yards

No.	Size	British Wire Gauge		= in 1000 of an inch		Suitable for
		Points	Centre	Points	Centre	rods up to
1	Fine	24 1/2	21	0.021	0.032	8 ft.
2	Medium	23 1/2	19 1/2	0.023	0.040	9 1/2 ft.
3	Stout Medium	22 1/2	18 1/2	0.026	0.046	10 1/2 ft.
4	Stout	22	18	0.028	0.048	11 ft.

Double Taper Salmon, 42 yards

No.	Size	British Wire Gauge		= in 1000 of an inch		Suitable for
		Points	Centre	Points	Centre	rods up to
4	Ex. Fine	21	18	0.032	0.050	12-13 ft.
5	Fine	20	17	0.036	0.056	13-14 ft.
5 1/2	Medium	19 1/2	16 1/2	0.040	0.060	14-15 ft.
6	Stout Medium	18 1/2	16	0.044	0.064	15-16 ft.
7	Stout	18	15	0.048	0.072	16-17 ft.

Most of the larger British manufacturers eventually limited their line designations to numbers. Each had their own system, though, and sometimes even half numbers were used. Diameters or weights were omitted in the catalogues, only recommendations for rod lengths or rather general descriptions like "fine", "medium", "stout" or "heavy" were printed.

Similar developments could be observed on the other side of the Atlantic. Gudebrod started silk line production in 1885, Ashaway in 1906, Cortland in 1916, to name only three. Alas, in the US a lettering system was established in addition to a numerical one. It used the first letters of the alphabet, from A (thick) to I (thin). The imported British lines with their numbers were not easily compared with domestic lines and their letters.

US line designations and diameters around 1900 were:

size	inch	mm	size	inch	mm
2 or 0/0	0.065	1.65	E	0.038	0.96
A	0.060	1.52	F	0.034	0.86
B	0.056	1.42	G	0.030	0.76
C	0.052	1.32	H	0.026	0.66
D	0.045	1.14	I	0.021	0.53

For comparison: American Wire Gauge No. 14 = 0.064 in, No. 24 = 0.020 in.

> Perry D. Frazer laments in his book "Fishing Tackle" (1914): "The calibers of fishing lines, as made by the different firms, are almost hopelessly confused. Some firms use what seems to be the original method – of employing the first nine letters of the alphabet – and others use nine figures. Then some reverse the order, so that a No. 6 line, say, is larger than a No. 1. Then again lines are numbered arbitrarily, so that a No. 3 and a No. 269 are alike in caliber but different in style of braiding and finish."

These examples may suffice. Fly fishers had a hard time choosing a proper line for their rod.

When the confusion was great enough, the NAACC[1] in the USA introduced a standard, which was generally accepted. It used a letter designation for the diameters, from I (thinnest) to AAAA or 4A (thickest), which was essentially a combination of both British and American wire gauge systems. The important thing was that a uniform size and diameter designation was established that could be relied upon for consistency regardless of manufacturer.

Tab. 1: NAACC diameters, both imperial and metric

"NAACC official standard table of fly line calibrations with letter designations, maximum permissible tolerances, and maximum permissible average deviations"

line size (designation)	nominal diameter (in)	tolerance minus (in)	tolerance plus (in)	nominal diameter (mm)	tolerance minus (mm)	tolerance plus (mm)	tolerance plus/minus (mm)
I	**0.022**	0.0205	0.0235	**0.56**	0.52	0.60	0.04
H	**0.025**	0.0235	0.0265	**0.64**	0.60	0.67	0.04
G	**0.030**	0.0275	0.0325	**0.76**	0.70	0.83	0.06
F	**0.035**	0.0325	0.0375	**0.89**	0.83	0.95	0.06
E	**0.040**	0.0375	0.0425	**1.02**	0.95	1.08	0.06
D	**0.045**	0.0425	0.0475	**1.14**	1.08	1.21	0.06
C	**0.050**	0.0475	0.0525	**1.27**	1.21	1.33	0.06
B	**0.055**	0.0525	0.0575	**1.40**	1.33	1.46	0.06
A	**0.060**	0.0575	0.0625	**1.52**	1.46	1.59	0.06
AA	**0.065**	0.0625	0.0675	**1.65**	1.59	1.71	0.06
AAA	**0.070**	0.0675	0.0725	**1.78**	1.71	1.84	0.06
AAAA	**0.075**	0.0725	0.0775	**1.91**	1.84	1.97	0.06
AAAAA	**0.080**	0.0775	0.0825	**2.03**	1.97	2.10	0.06
AAAAAA	**0.085**	0.0825	0.0875	**2.16**	2.10	2.22	0.06

"1. Sizes larger than 5A shall be specified only by diameter in thousandths of an inch.
2. The maximum permissible tolerance, plus or minus, shall be one-half of the difference between the nominal diameter and the nominal diameters of the adjacent sizes or 2 $^1/_2$ thousandths on all letter sizes, except I and I to H which are 1 $^1/_2$ thousands.
3. The maximum permissible average deviation throughout the length of the line shall not exceed one thousandths of one inch, plus and/or minus."

[1] In 1907 the National Association of Scientific Angling Clubs (NASAC) was formed in Kalamazoo, Michigan. In1939 the NASAC changed its name to National Association of Angling and Casting Clubs (NAACC). In 1960 it changed its name again to the American Casting Association (ACA).

It was no easy task to stay within the tolerance limits of plus/minus 0.001 in. = 0.0254 mm for the length of the line.

The standard said nothing about the length of the total line, or the tapered parts of it. Only the body diameter calibrations were defined. The length of the tapered portions could vary from several feet to 10 yards. Usual taper lengths were 10 or 12 feet for trout lines. Salmon lines had considerably longer ones.

It was recommended that double taper trout lines be tapered to a diameter equivalent to the wire gauge number 22, which corresponds to the letter H, and double taper salmon lines to a diameter equivalent to wire gauge number 20, or the letter F.

The line size on the box of a trout line, e.g. would read “HDH” which indicated a diameter of 0.64 mm/0.025 in. at one end (tip), a diameter of 1.14 mm/0.045 in. for the level, or parallel part of the body, and 0.64 mm again at the other end. A salmon line could have the designation F2AF, which translates into 0.89/1.65/0.89 mm = 0.035/0.065/0.035 in. Weight forward (WF) lines, in the beginning also called Torpedo Head, Forward Taper or Balanced Taper, had a similar designation. The diameter of the "running-line" usually was one or two sizes larger than the tip diameter, for example, HDG or HDF.

Fig. 1: British and American Wire Gauge diameters with NAACC Standard (letters) and allowed tolerances
(see Tab. 1).

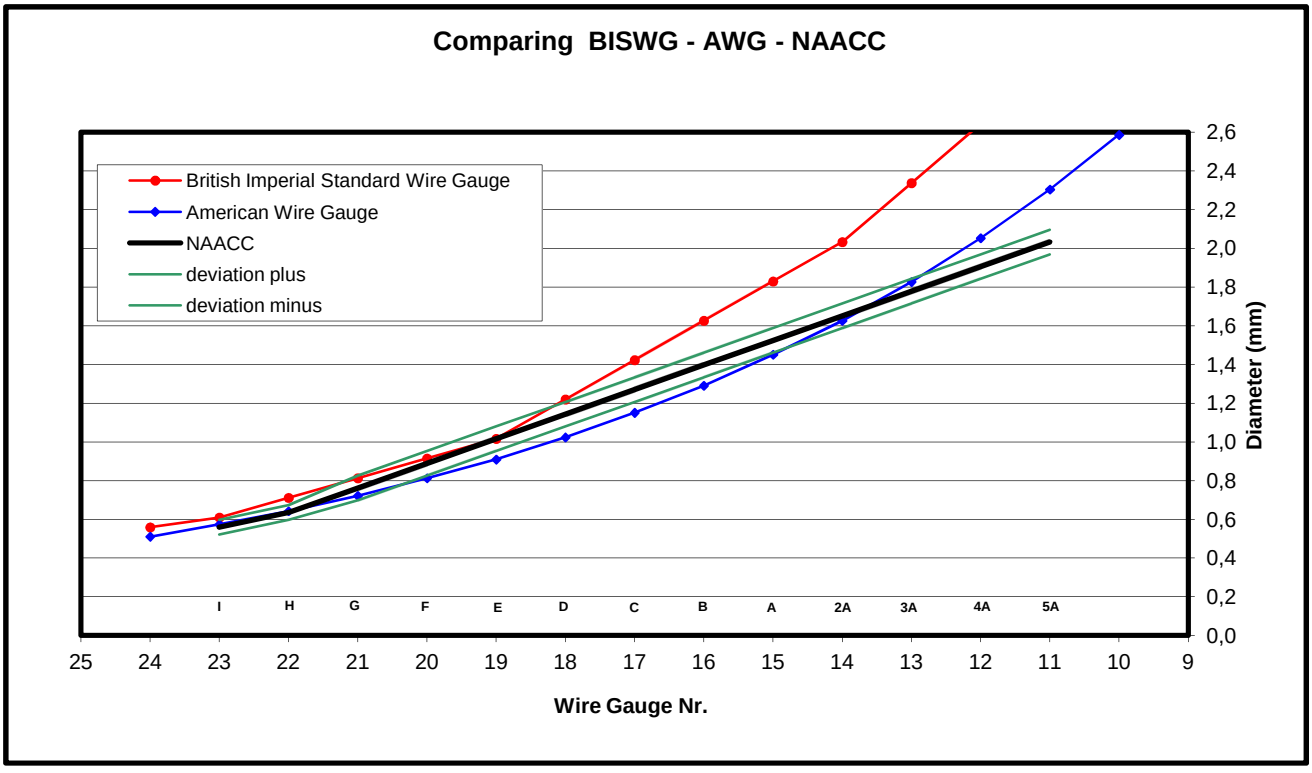
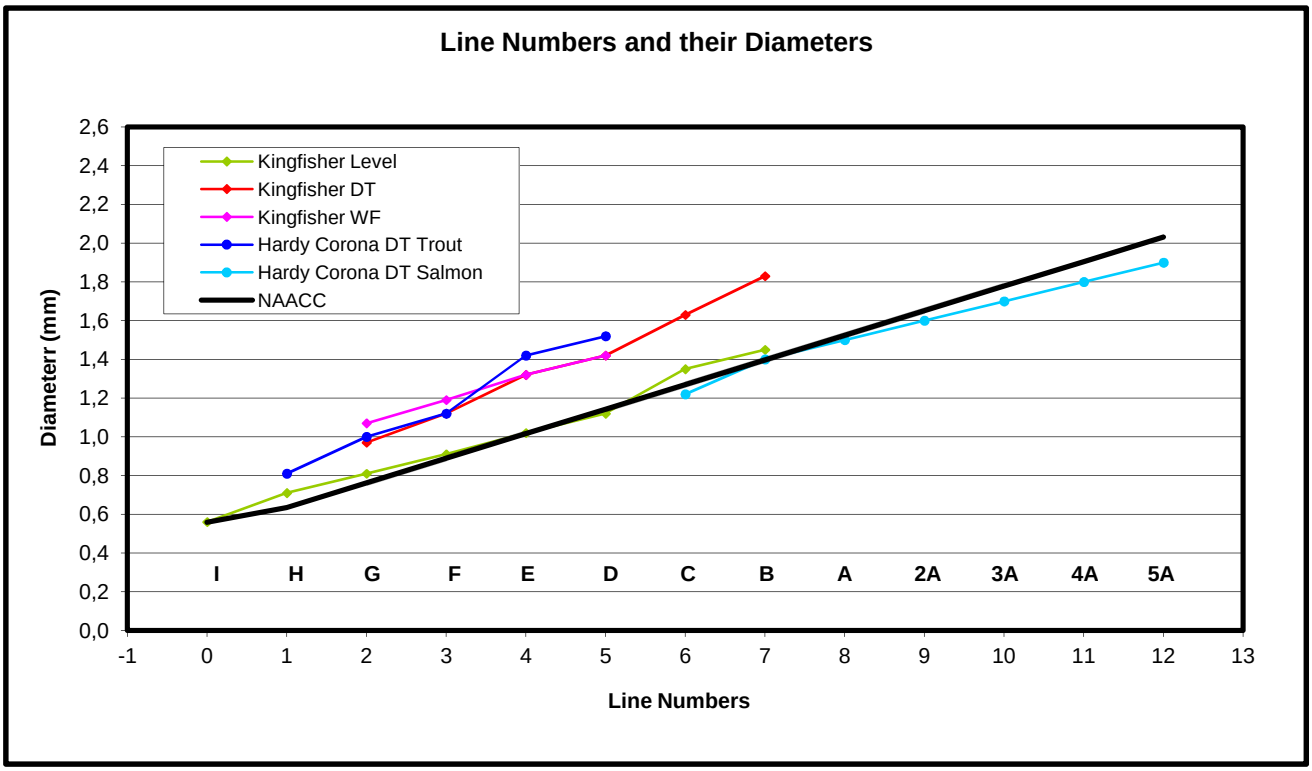
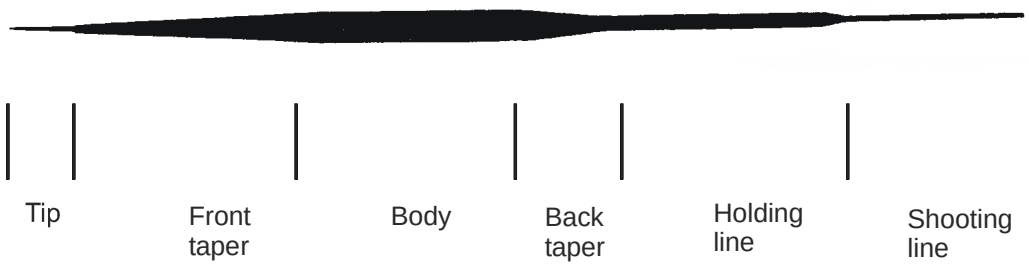


Fig. 2: Line numbers as designated by the manufacturers with actual diameters. Included, for cross reference, the NAACC-letter designations and their approximate positions with respect to the line numbers.



The "Kingfisher-Level" lines, numbered 0 to 7, were rather near the NAACC-letters I to B, and well within the allowable tolerances. Number 4 (1.02 mm = 0.040 in.) was exactly the diameter of E. Diameters of both "Kingfisher" DT and WF lines number 4 however, were much thicker, as many as 2 or 3 letter designations, something like C or B.
The "Corona Trout" Nr. 4 (1.42 mm = 0.056 in.) was almost as thick as the "Kingfisher Level" No. 7 (1.45 mm /0.057 in.) the same thickness as "Kingfisher DT" No. 5 or "Kingfisher WF" No. 5, and thicker than "Corona Salmon DT" Nr. 7 (1.40 mm = 0.055 in).

Besides level lines, mainly produced for baitcasting and general fishing purposes, but also for fly fishing, and double tapered lines for fly fishing only, weight forward lines were also marketed by all the larger companies. Many of them had a rather complex tapering. Below are dimensions and weights of the celebrated "Farlow's Holdfast Balanced Taper" lines, of brown colour. Lines numbered 1 to 4 were designed for rods of 8 to 10 feet, numbers 5 and 6 were for two-handed rods of 12 and 13 feet.



Farlow's "Holdfast" Balanced Taper Lines

Line Number	Tip		Front taper	Body		Back taper	Holding line		Shooting line		Casting weight (body)	Total length
	Length (ft/in)	Diam (mm)	Length (ft/in)	Length (ft)	Diam (mm)	Length (ft)	Length (ft)	Diam (mm)	Length (ft/in)	Diam (mm)	(grams)	(yards)
1	3'	0,63	10' 6"	15'	1,02	3'	15'	0,89	43' 6"	0,76	11,0	30
2	3'	0,63	12' 6"	15'	1,15	4'	16'	0,89	42' 6"	0,76	16,5	31
3	3' 3"	0,63	14' 0"	16'	1,27	5'	16'	0,89	44' 9"	0,76	18,5	33
4	3' 3"	0,63	16' 0"	16'	1,40	5'	18'	0,89	43' 9"	0,76	24,5	34
5	2' 9"	0,89	13' 6"	18'	1,40	6'	14'	1,02	72'	0,89	25,5	42
6	2' 9"	0,89	18' 3"	20'	1,52	8'	16'	1,02	72'	0,89	35,0	46
Hedge	3'	0,51	12'	10'	1,14	3'	18'	0,89		0,63		

Included for comparison is the data for a "Hedge 7-Taper Balanced Fly Line", developed by Marvin K. Hedge. In 1941 he was granted US Patent No. 2,250,832 for a WF-line. Possibly the "Holdfast"-range of lines were an answer to Hardy's "Tournament"-lines (Marvin K. Hedge Taper), see above.

> The complete dimensional description of the "Hedge 7-Taper Balanced Fly Line": "Shooting line or backing, of 0.025" diameter; final back taper of 2' in length, tapered from 0.025" to o.035"; reinforced holding line of 18' in length, 0.035" diameter; back taper of 3' length, tapered from 0.035" to 0.045"; belly section of 10' in length, 0.045" diameter; 5 graduated tapers from 0.045" to 0.020", 12' in length; point of 3', 0.020" diameter".

Of course other producers had similar lines. Hardy introduced the "Filip" Special Tapered Salmon & Trout Lines in 1911, 50 yards for salmon in 4 sizes and 35 yards for trout in 3 sizes. Kingfisher omitted the "holding line" section in their WF lines, and provided a level "shooting-line", only.

Kingfisher Balanced Taper Lines

Line Number	Tip		Front taper	Body		Back taper	Shooting line		Casting weight (body)	Total length
	Length (ft)	Diam (mm)	Length (ft)	Length (ft/in)	Diam (mm)	Length (ft)	Length (yards)	Diam (mm)	(grams)	(yards)
Trout										
2	1'	0,71	11'	13'	1,07	2'	21	0,74	21	30'
3	1'	0,76	11'	13'	1,19	2'	21	0,81	25	30'
4	1'	0,89	11'	13'	1,32	2'	21	0,94	28	30'
Salmon										
4	1'	0,89	14'	16' 6"	1,32	2'	29	0,94	39	40'
5	1'	1,02	14'	16' 6"	1,42	2'	29	1,07	48	40'

Today these lines would be called "Shooting Head" or "Short Belly" lines.

There were still other varieties of silk lines available. There were short DT lines (Farlow's "Shorter"), of 22 yards length for trout and 32 yards for salmon. The argument in favour of these lines was that since only very few anglers needed the last 10 yards of their lines while fishing, it was impractical to carry an unnecessarily large amount of expensive line on their reels. "Single Taper" lines were also marketed, usually 20 yards in length. Transparent lines are nothing new, either. The US firm B.F. Gladding marketed a "Trans-Lu-Cent"-line in 1937, which was "transparent grey-green" and therefore "less visible for the fish".

And there were Silk Floss Dapping lines, which were not really casting lines but nevertheless much used for drift (fly) fishing from a boat. They were made in 20 yard lengths, and in 3 sizes: Fine, breaking strain 12 lb; Medium, breaking strain 16 lb; Stout, breaking strain 20 lb.

Back to the NAACC.

The letter designation defined the **diameter** of a line only, plus or minus a certain tolerance, independent of the weight.

Now, silk lines were and are braided with machines (much like a boot-lace, not twisted like ropes). The operator can make a loose braid or a tight one, with many thin or fewer thick threads. A loose braid consumes less silk (a cost factor), and the line will be more pliable and have a considerable stretch. A tight braid uses more silk, and the line is much stiffer, shooting well. Lines were made "supple", "medium" or "wiry". The "wiry" ones were recommended for lines up to letter C, "medium" or "supple" for larger sizes.

The impregnation process can involve a vacuum treatment or not, and after that a thin or a thick layer of dressing can be put onto the surface of the line. Up to 12 layers were put on by some makers, also to fill the tiny "holes", or interstices in the braid. A smooth (and stiff) line shoots better through the guides. Furthermore, different impregnation substances were applied. Each producer had (and still has) his own secret potion with its own specific weight. All of this causes different weights per unit length. I have identified specific weights ranging from 0.82 (!) to 1.57 g/cm^3 (grams per cubic centimeter) = 51.19 to 98.01 lbs/ft^3 (pounds per cubic foot). Most silk lines are in the region of 1.2 to 1.3 g/cm^3.

Pure silk has a specific weight of typically 1.33 g/cm^3. Pure linseed oil one of 0.93 g/cm^3

> Linseed oil has the property of drying or becoming solid on exposure to the air, and increasing as much as 12 % of its weight, owing to the formation of *linoxyn* by atmospheric oxidation. The drying property resides in a constituent which, to distinguish it from the olein of the non-drying oils, is named *linolein*, and is the glyceride of *linoleic acid*.

The dressing in/on a silk line, principally linseed oil, comprises 35 to 50 percent of the finished line's total weight, with about 40% being the average. A calculation (60% silk plus 40% linseed oil) results in a specific weight of 1.17 g/cm^3, provided there is no air trapped in the braid. It is a line, which is slightly heavier than water (1.00 g/cm^3), and accordingly a line which will sink slowly, i.e. an "intermediate". If you grease it with, for example, "Mucilin Red", Hardy's "Cerolene" or Farlow's "Floataline", it will "swim" The surface-tension of the water holds it afloat.

Then, in 1934, Nylon was invented and patented by Du Pont. It was called Nylon 66. In 1939 the first unsinkable plastic lines and leaders were marketed (Ashaway). By the way, before ladies' stockings! The first commercially successful line was the "Cortland 333", which was introduced in 1953. Of course it was labelled according to the NAACC letter standard. It had a hollow braided tapered nylon core and a vinyl coating (PVC), which was introduced in 1949. When this coating became porous, or suffered from cracks, the line was quickly turned into a sinking line. Braided lines were also made from this new material, as were lines with mixtures of silk and nylon. They were impregnated and dressed like silk lines and had about the same properties (intermediate). Ashaway became especially famous for this type of lines, and a friend, who owns 6 or 8 such lines (WF ones), still fishes them for salmon in Norway and Sweden. They have differently coloured parts: front taper green, body amber, back taper green, running line, in segments, amber, brown and red. A sinking version was also made, of the much heavier Dacron. Furthermore there were DT lines (Milward's Twincraft), whose one half was made of Nylon (swimming), and the other half of Terylene, a polyester (sinking,). Both ends were provided with loops to facilitate a quick change. They were even made with two WF-parts: the Nylon-half as a HEI and the Terylene-half as a HCI.

Spec. weight Nylon 66:	1.15 g/cm^3
Spec. weight Polyesters:	1.22 – 1.38 g/cm^3
Spec. weight PVCs:	1.30 – 1.58 g/cm^3

In 1954 Scientific Anglers began production of their "AirCel" lines, which had a level braided core and a tapered PVC-coating filled with microscopic hollow glass-spheres, to make the line float. (Adding 3% by weight of microballoons with a density of 0.18, which is approx. 1/5 that of water (1.00) to a PVC with a density of 1.30 reduces the coating's specific weight to 0.95).

These lines floated due to the new material combination, which was **lighter** than water. A Nylon/PVC-HEH line e.g. was much lighter than a Silk-HEH. Anglers had to use one size thicker (= heavier) with these new lines, to make their rods function as before. Shortly afterwards another (sinking) line type was introduced, the "WetCel", which was much heavier than silk, and which aggravated the problem. Anglers had to go one size thinner than silk. Eventually conversion tables were published, to match the new material's line sizes (letters) to the well known silk line designations. (Meanwhile more synthetic materials, like Polyester, Polyurethane,

Polyethylene, Kevlar, PTFE are used for fly lines, both for the core and for the coating, all with different specific weights).
This new confusion had to be rectified.

In 1958 Myron Gregory, president of the ICF (International Casting Federation) proposed a resolution to the NAACC for a new line standard, which was approved. Soon after, the AFTMA[2] formed a committee whose work resulted in the 1960 adoption of a New Standard. This system is based on line weight only, namely that of the first 10 yards/30 feet/9.14 meters of a line, regardless of material density or taper configuration. These 10 yards were required to have a certain weight measured in "grains avoirdupois", plus-minus a certain tolerance, also measured in grains. It is a numerical system, with No. 1 originally designating the lightest and No. 12 the heaviest line. Today lines No. 0 and lines No. 13 to 15 and above are produced.

The number-designation possibly reflects somewhat the old English numbering-pattern for silk lines, where thin, (hence light) lines had low numbers and thick (heavy) ones, much used for salmon fishing with two-handed rods, had high numbers from 10 to 12.

Tab. 2: Weights of AFTMA line numbers and allowed tolerances, both imperial and metric.
In addition the calculated weight of one meter.

"AFTMA Fly Line Weight Standards"

Line Size **AFTM**	weight 30 feet = 10 yards = 9.14 m	lower tolerance 10 yards = 9.14 m	upper tolerance 10 yards = 9.14 m	weight 30 feet 10 yards = 9.14 m	lower tolerance 10 yards = 9.14 m	upper tolerance 10 yards = 9.14 m	tolerance plus-minus 10 yards = 9.14 m	weight 1 meter = 1.093 yd = 3.280 ft
Nr.	grains	grains	grains	grams	grams	grams	grams	grams
0	**56**	54	58	**3.63**	3.50	3.76	0.13	0.40
1	**60**	54	66	**3.89**	3.50	4.28	0.39	0.43
2	**80**	74	86	**5.18**	4.80	5.57	0.39	0.57
3	**100**	94	106	**6.48**	6.09	6.87	0.39	0.71
4	**120**	114	126	**7.78**	7.39	8.16	0.39	0.85
5	**140**	134	146	**9.07**	8.68	9.46	0.39	0.99
6	**160**	152	168	**10.37**	9.85	10.89	0.52	1.13
7	**185**	177	193	**11.99**	11.47	12.51	0.52	1.31
8	**210**	202	218	**13.61**	13.09	14.13	0.52	1.49
9	**240**	230	250	**15.55**	14.90	16.20	0.65	1.70
10	**280**	270	290	**18.14**	17.50	18.79	0.65	1.99
11	**330**	318	342	**21.38**	20.61	22.16	0.78	2.34
12	**380**	368	392	**24.62**	23.85	25.40	0.78	2.69
13	**450**	435	465	**29.16**	28.19	30.13	0.97	3.19
14	**500**	485	515	**32.40**	31.43	33.37	0.97	3.54
15	**550**	535	565	**35.64**	34.67	36.61	0.97	3.90

Line sizes: 0, 13, 14, 15 not approved AFTM-Standard

Units mentioned in this paper

1 pound =	16	ounces	1 ounce =	437.5	grains
=	7000	grains	=	16	drachms
=	453.59237	grams	=	28.35	grams
			1 grain =	0.0648	gram
			1 yard =	0.9144	meter
			1 foot =	0.3048	meter
			1 inch =	25.4	millimeters

[2] AFTMA = American Fishing Tackle Manufacturers Association, later AFTM = American Fishing Tackle Manufacturers, now ASA = American Sportfishing Association

New on the market are lines in half and even quarter line numbers (weights). I consider this unnecessary and little short of nonsense. The difference, e.g. between 10 yards AFTM 4 and AFTM 5 is 20 grains = 1.29 grams. 10 yards of a $4^1/_2$ –weight line, then, would be 10 grains heavier than 10 yards of a 4–weight. One meter of a 4–weight line weighs 0.85 grams = 13.117 grains (see table above), and 0.76 meters weigh 10 grains = 0.648 grams. It amounts to having a mere 0.76 meters = 2.49 ft. more of a 4–weight line outside the top guide, to achieve the same loading of your rod as with a $4\ ^1/_2$ –weight line. The allowed tolerances are plus/minus 6 grains = 0.3888 grams. 10 grains is very near this range, and quarter-weight-lines (5 grain-steps) would be well within it. The air-resistance of such lines due to greater diameter, and hence the "feeling", would not be dramatically different, either, all other things being equal. Material properties of different line brands, such as elasticity and specific weight are liable to play a larger role.

Many producers of lines - and possibly also their customers - had a hard time putting the new AFTM Standard to use. Pezon et Michel, e.g. printed no less than 3 line designations on their boxes: The old designation with NAACC letters, their own numbering system, and the new AFTM numbers. For example: "HEH, No. 2, AFTM 4". Additionally, on a paper sheet inside the line box, they included a table with weights of 9.14 meters of their 30 yards long lines (double fuseau = DT, fuseau décalé = WF).

Tab. 3: Pezon et Michel (France) line designations

Producer Declarations					**Producer Declarations**				
line "Parabolic" double fuseau Nr.	AFTM Nr.	approx. weight 9.14 m (grams)	weight designation AFTM (grams)	difference (grams)	line "Parabolic" fuseau décalé Nr.	AFTM Nr.	approx. weight 9.14 m (grams)	weight designation AFTM (grams)	difference (grams)
1	3	7	6.48	0.52	D 2	6	11	10.37	0.63
2	4	8	7.78	0.22	D 3	7	12	11.99	0.01
3	6	10	10.37	-0.37	D 4	8	13	13.61	-0.61
4	7	12	11.99	0.01	D 20	10	19	18.14	0.86
5	9	16	15.55	0.45	D 40	12	24	24.62	-0.62

The line weights are very near the required AFTM values. Obviously, lines were produced to comply with AFTM standards and additionally labelled with the old NAACC letters, which many of their older customers were more used to. Notice that some AFTM numbers never existed/were produced.

Other producers, too, put both designations on their line boxes, eventually omitting their own numbering system. But the time of silk lines was running out. They were replaced by synthetic lines.

Since its introduction in 1960 the AFTM-system has served many anglers very well. Alas, for salmon-fishers using two-handed rods of 12 to 16 feet and beyond it was not quite as suitable. Usually, a two-hand-caster requires much more than 10 yards outside his top-guide to load his rod properly. Also water casts, like the spey, require more line activity for good results. And the new carbon-rod-generations of recent years only work perfectly with a precisely determined length of line, with a likewise precisely determined amount of weight.

Again this led to confusion and misunderstandings among anglers and the fishing tackle trade (especially between producers of lines and rods).

In recent years a committee of both fishermen and line technicians from the industry sat together and eventually proposed yet another New Standard, this time expressly for so called spey lines to the AFFTA (American Fly Fishing Trade Association). It has been approved and the table below lists the parameters of this latest addition to line standards.

Tab. 4: **"AFFTA approved spey line weight standards"**

	Shooting Head		Short Belly		Medium Belly		Long Belly	
Line Style	H		S		M		L	
Head Length	30 – 50' 9.14 – 15.24 m		50' – 60' 15.24 – 18.29 m		60' – 70' 18.29 – 21.33 m		70' plus 21.33 m plus	
Weight Point	40' 12.19 m		55' 16.76 m		65' 19.81 m		80' 24.38 m	
Line Weight Number	weight		weight		weight		weight	
	grains	grams	grains	grams	grains	grams	grains	grams
6	250	16.2	420	27.3	460	29.9	600	39.0
7	300	19.5	470	30.5	510	33.1	650	42.2
8	360	23.4	530	34.4	570	37.0	710	46.1
9	430	27.9	600	39.0	640	41.6	780	50.6
10	510	33.1	680	44.2	720	46.8	860	55.8
11	600	39.0	770	50.0	810	52.6	950	61.7
12	700	45.5	870	56.5	910	59.1	1050	68.2

"Head length to include the head and back taper to the holding line and/or running line."

It is, after all, the weight of a line, or a certain length thereof, which we cast and not the diameter. This was well known to anglers a hundred years ago.

H.P. Wells writes in his book "Fly Rods and Fly Tackle" (1901, 2nd enlarged ed. p. 65): "Third. We must have weight, not only to bring out the action of the rod, but also that the line will hold its own, at least to some extent, against the wind,... The momentum of the line in the act of casting is measured by its weight multiplied by its velocity...." and continues: (p. 71, p. 49 in the 1st edition 1885) "Now I am inclined to believe that five and a half times the length of the rod approximates pretty closely to the limits of efficient casting in actual fly-fishing, ... Therefore, if it be wise to adapt your tools to your every-day work, ... it would seem that the beginner would do well to use no line heavier than a level E ..."

This was written at the time of single-handed 10 to 12 foot trout rods made of Greenheart, Lancewood, Snakewood or Calcutta Cane. 50 feet (15.2 m) of a US - "level E line" of the time, diameter 0.038 in/ 0.96 mm (see page 6), weighed approximately 13.2 grams/204 grains, which is the weight of 38 feet of an AFTM # 6 line, or 44 ft of a # 5, or 51 ft of a # 4

How can the old numbering or lettering systems, based on diameter only, be converted to the new AFTM-numbering system, which is based on weight only?

Simple enough: just weigh 30 feet of a line and compare with the AFTM designations/ weights (Table 2).

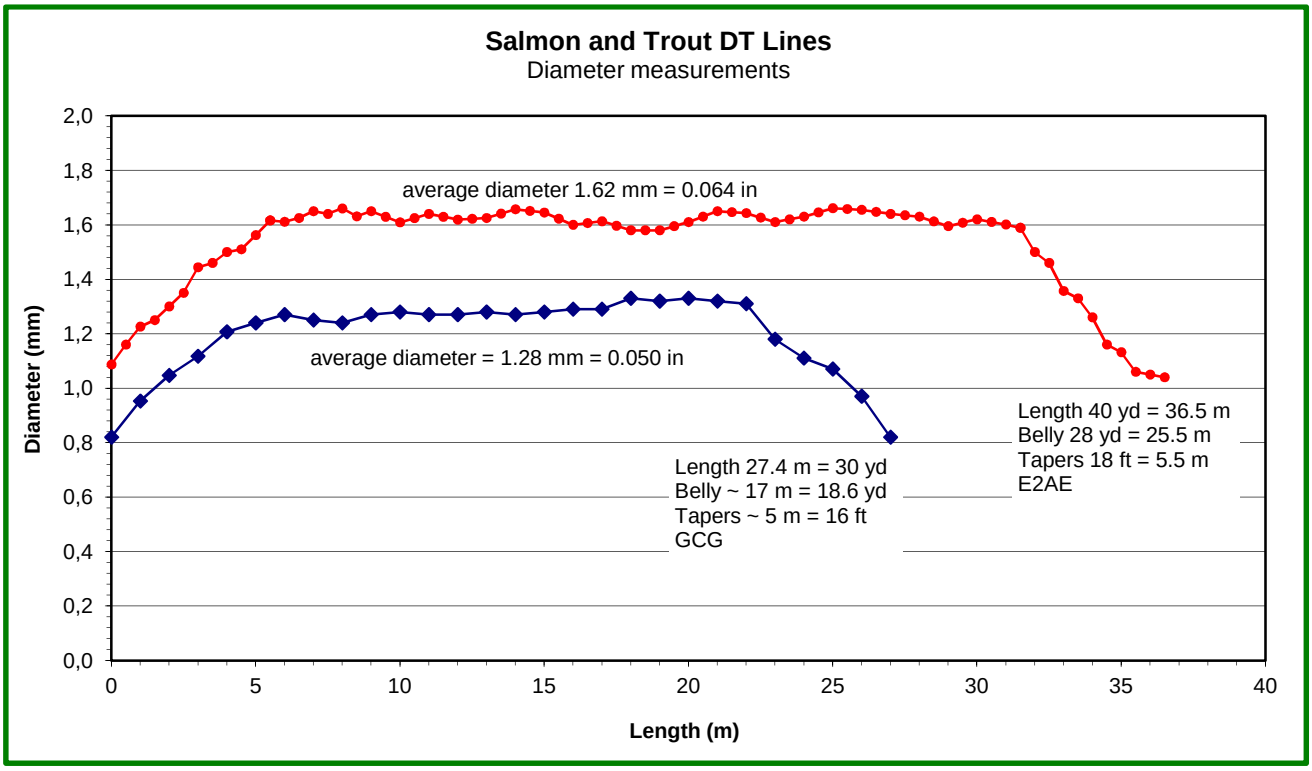
The other way to go is via the specific weight.

First, measure the length of a silk line. Then the diameters of the tips, the lengths of both tapered parts (DT lines) and the diameter of the parallel, main part of the line, the latter along the whole length of the line, approximately every yard or so, making two measurements at 90° to each other at every point (careful, you don't want to squeeze it). Lines are often oval or otherwise "unround", and you want as many measurements as possible to calculate a reliable average diameter. Then you weigh the line, in grains, or as exact as one-tenth of a gram.

With these data you can calculate the volume (for formulas see a math book) of a line: one cylindrical part (the main body) plus two conical parts (the two end-tapers), plus maybe two more cylindrical parts, the approximately 1 to 3 feet long parallel "tips" of the line. The last ones are often missing, at least with used lines. Having calculated the volume (and measured the weight), you can determine the specific weight, in grams per cubic centimeter or pounds per cubic foot (metric or imperial). Next, you calculate the weight of the tapered part and that of the parallel part. Next that of one foot, or yard, or meter, or the weight of 10 yards/30 feet (in grains or grams), which is the basis for the AFTM system. One further calculation brings you to the (calculated) correct AFTM number. Similar calculations can be performed for weight-forward (WF) lines, and for other shapes.

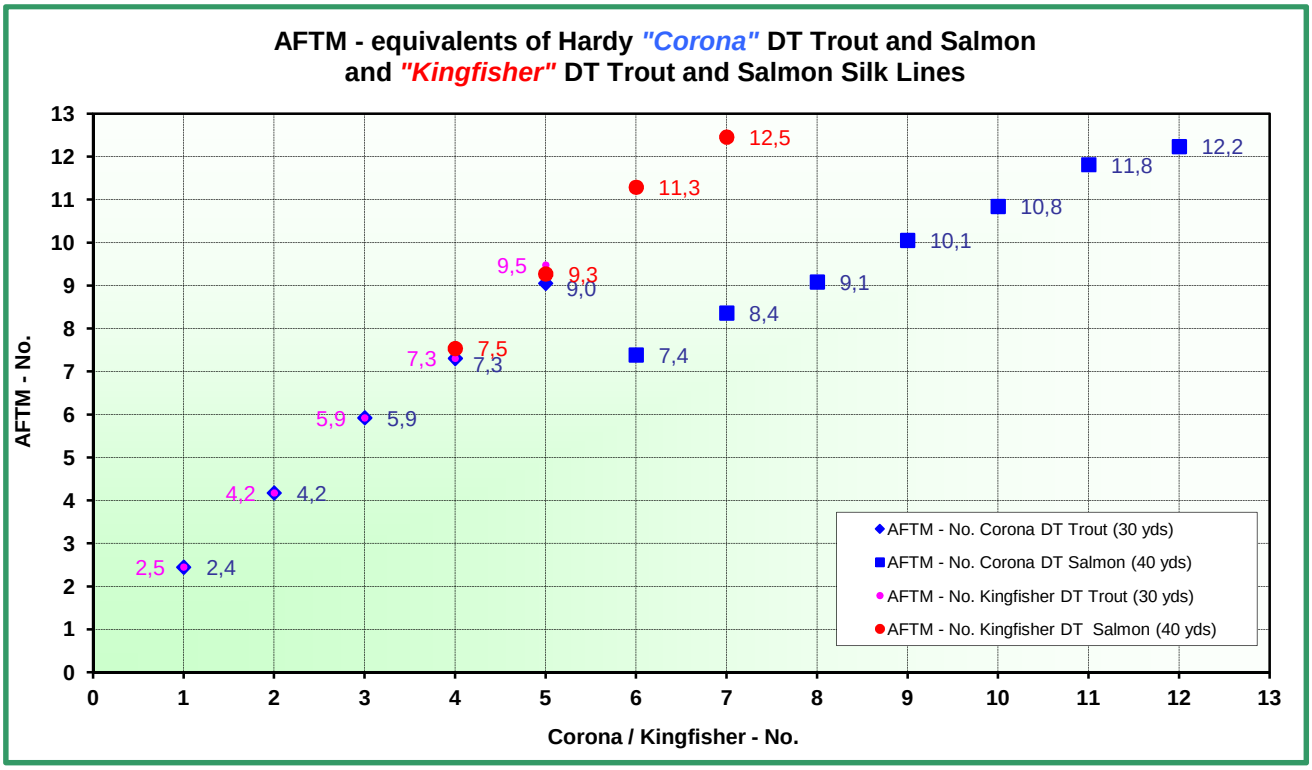
I have made such measurements and calculations for a number of silk lines, both old ones and some by today's makers.

Fig.4: Measured diameters of two DT lines.



As an example, the diameters of two vintage DT silk lines, measured in 0.5 and 1.0 m increments, as explained above and plotted in a graph. Average diameter of level parts 1.62 mm = 0.064 in. and 1.28 mm = 0.050 in.

Fig. 5: Calculated AFTM line numbers of "Kingfisher" and "Corona" lines



"Corona Trout" and "Kingfisher Trout" numbers are all but identical. They were produced in the same factory, after all. Hardy's "Corona Salmon" numbers, though, differ from Kingfisher's Salmon-line designations. A "Corona Trout No. 2" would translate to AFTM 4.2, just like a "Kingfisher Trout No. 2". A "Kingfisher Salmon No. 7" corresponds with AFTM No. 12.5, a "Corona Salmon No. 12" is equivalent to AFTM No. 12.2. Tolerances are not included.

There are a number of tables available (books, old catalogues, internet), which compare the old NAACC letter system with the new AFTM number system. They serve the purpose well enough, and with sufficient precision. Below I have added yet another such table, applying the calculations outlined above (page 13). A taper length of 6 feet was used for all lines, and three different specific weights were calculated (1.20, 1.30 and 1.40 g/cm^3, respectively, see page 10).

Tab. 5: Calculated AFTM-weights of NAACC letter designations (see Tab. 1, allowed tolerances not included)

NAACC Line Letter Designation	Volume Taper Part 6 feet 1.828 m (cm^3)	Volume Level Part 24 feet 7.315 m (cm^3)	Volume 10 yards 30 feet 9.14 m (cm^3)	Weight 10 yards 30 feet 9.14 m (grams)	Weight 10 yards 30 feet 9.14 m (grains)	AFTM number calculated spec. weight 1.20	AFTM number calculated spec. weight 1.30	AFTM number calculated spec. weight 1.40
IFI	0.77	4.54	5.31	6.37	98.3	**2.91**	**3.32**	**3.73**
HFH	0.84	4.54	5.38	6.46	99.7	**2.98**	**3.40**	**3.81**
HEH	1.00	5.93	6.93	8.31	128.3	**4.41**	**4.95**	**5.48**
HDH	1.17	7.51	8.67	10.41	160.6	**6.02**	**6.56**	**7.09**
HCH	1.35	9.27	10.62	12.74	196.6	**7.47**	**8.12**	**8.78**
GBG	1.72	11.21	12.93	15.52	239.5	**8.98**	**9.65**	**10.32**
GAG	1.95	13.34	15.29	18.35	283.1	**10.08**	**10.67**	**11.26**
GAAG	2.19	15.66	17.85	21.42	330.5	**11.01**	**11.56**	**12.11**
GAAAG	2.44	18.16	20.60	24.72	381.5	**12.03**	**12.67**	**13.30**
GAAAAG	2.71	20.85	23.56	28.27	436.3	**12.80**	**13.32**	**13.84**

Buying an old HEH line, then, you may end up with anything between AFTM 4$^1/_2$ and AFTM 5$^1/_2$, the reasons for said variance I have tried to explain.

Refinishing this HEH line completely, with new impregnation and surface-dressing, allows you to "manipulate" the weight a whole number up or down, or even more.

A calculation example, in metric units (for imperial see tables above):

10 yards/9.14 meters of a level line No. E with a nominal diameter of 1.02 millimeters have a volume of pi times radius squared times length = 3.14 x 0.026 x 9140 = 7464 mm^3 (cubic millimeters), and a calculated weight of 8.73 grams/134 grains (7.464 x 1.17, the calculated specific weight value from page 10), which is equivalent to a "heavy" AFTM 4-weight or a "light" 5-weight line (see Table 2).

Applying an additional layer of 0.05 mm (= 0.0019 in) dressing onto this line increases the diameter by 2 times 0.05 = 0.1 mm to 1.12 mm, or to a volume of 9000 mm^3, or plus 1535 mm^3. This is equivalent to 1.43 grams of linseed oil with the specific weight of 0.93 g/cm^3 (see page 10). You have all but created a D-line, nominal diameter 1.14 mm. In other words, you have "added" more than one AFTM-number. The weight difference (10 yards) from AFTM 4 to 5 is 1.3 grams = 20 grains.

Producing AFTM line weights in quarter-steps is not farther away than a very thin layer of dressing, of about one-fourth the above thickness of 0.05 mm = 0.0125 mm = 0.00049 in.

In 1978 Noel Buxton, of Sutton Coldfield, United Kingdom started to develop a new range of silk lines to comply with the AFTM Standards. He was dubbed an outdated traditionalist, but persisted in his efforts. Eventually he marketed his first DT lines in the most used numbers, 5 and 6. In May 1983, at the insistence of a Scottish angler, he dyed a proportion of his lines olive green and introduced the "Phoenix Mere Green". Towards the end of the year he extended the size range to include a lighter line of AFTM rating DT 4 and

introduced two 40 yard Salmon lines, in AFTM ratings of DT 10 and DT 12. In 1984, the requests for even lighter lines continued, and he introduced a DT 3 and started to develop a DT 2. 1986 brought a request from an American angler to produce a line range with extended tapers, and by 1989 he was able to offer these DCS lines in the whole AFTM weight range from # 1 to # 12. 1992 brought a request from a Japanese rod maker for # $^{1}/_{2}$ -weight lines.

His range of lines included:

"The Phoenix Original", a 30 yard trout line with relatively short, 4 foot tapers, in sizes 3, 4, 5, 6.
"The Phoenix DCS", a 30 yard 16 carrier line with 10 foot tapers, in sizes 1 through 9.
"The Phoenix DCS Salmon", of the same construction but with an overall length of 40 yards, in sizes 9 through 12.
All lines were available in either "Light Straw" or "Mere Green".

Noel Buxton has passed away in 2005.

Today Phoenix lines are produced in France, by Mike Brooks. He has extended the original range to WF lines of 33 yards length. The tapers of his lines are 6 feet long. In addition to DT and WF lines he produces Level lines in 25 m lengths, and in 4 diameters, from 0.65 to 0.90 mm (designated AA, B, C, D, corresponding roughly to AFTM 2-5) and also braided silk leaders in a number of sizes. http://www.phoenixlines.com/

Another producer of silk lines in France is J.B. Thebault, who also makes lines according to the AFTM standard in a number of sizes and lengths, both DT and WF. http://www.jpthebault.com/

Furthermore there is a "Loukkas" silk line brand from France
http://www.ffpml.com/ACCUEIL/loukkas/comind.htm

In Italy there is a Terenzio Zandri, who produces braided lines, both in silk and in "artificial silk" (PVC), in half- and quarter sizes, and also leaders. http://www.terenziosilklines.com/

Until recently there was a brand "Robinson", of Entreprise Marze in Saint Chamont, France and a company "Kaizer" in Belgium, which also had made "Luxor" lines for Pezon et Michel at one time. Both companies have ceased to exist.

Fig. 6: Selected silk lines and their AFTM designations

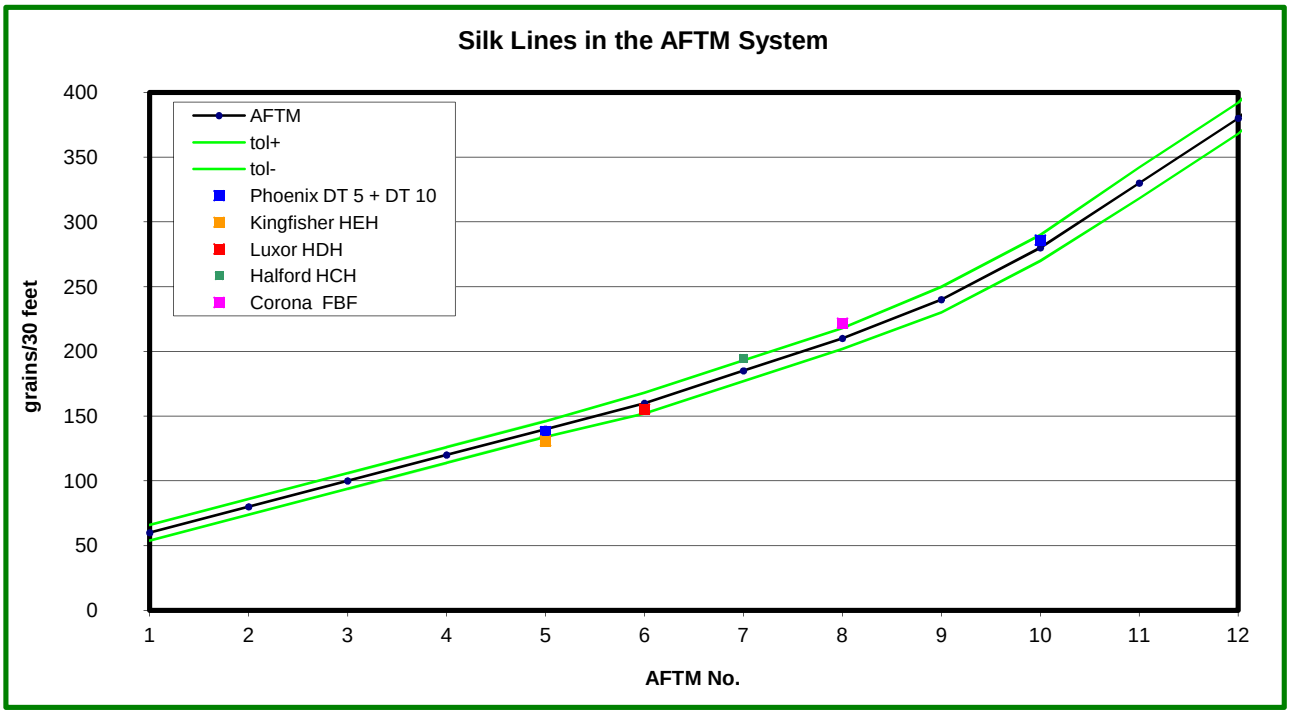
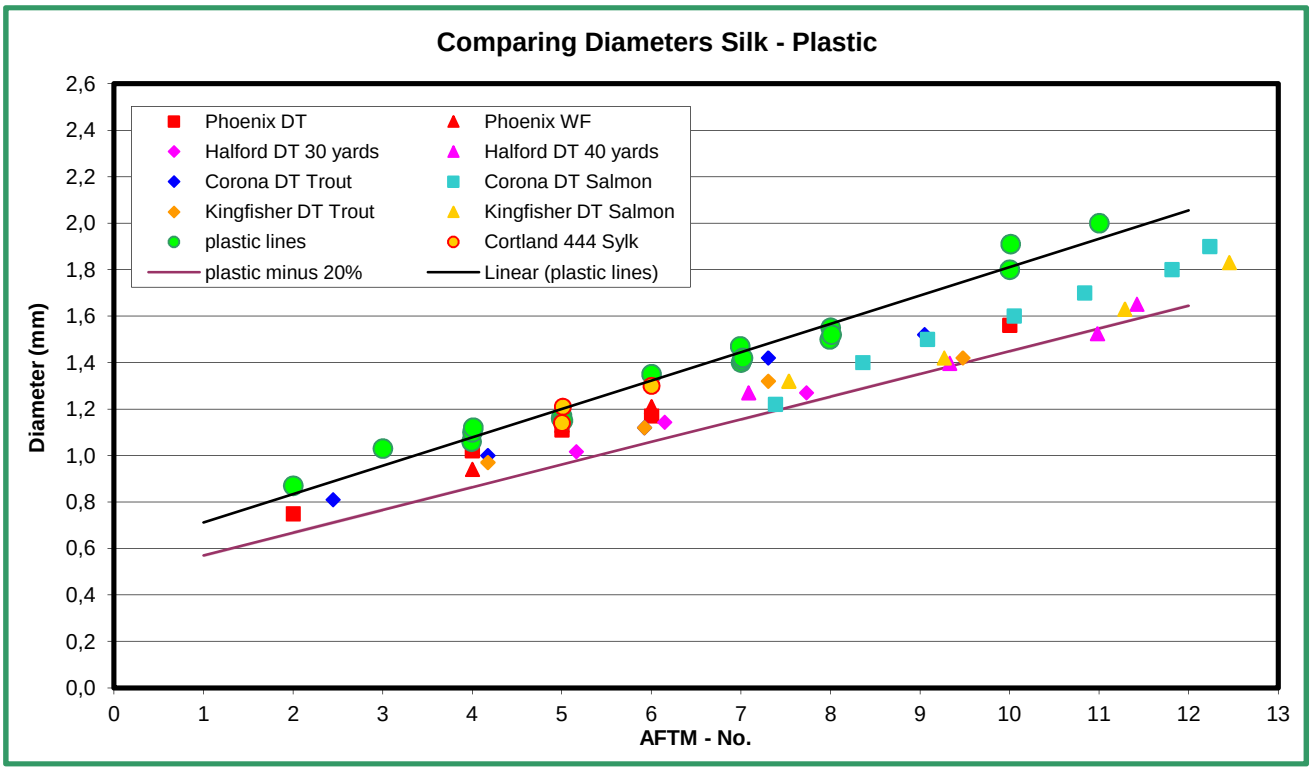


Fig. 6 shows a few selected silk lines and how they fit into the AFTM system. Two new ones, constructed to comply with AFTM standards (Phoenix) and four "old" ones, which have been measured and recalculated to

AFTM sizes. The black line represents the AFTM weights in "grains/30 feet", in green the allowed tolerances, plus and minus. The two Phoenix lines comply rather exactly with their designated weights, 5 and 10, respectively. The two "Kingfisher" and "Luxor" are close to the lower tolerance curve, so to speak "light" 5- and 6-weights, whereas the two "Halford" and "Corona" lines are rather "heavy" 7- and 8-weights, respectively.

How do silk lines compare to modern synthetic lines?
I have measured a number of plastic lines, all floaters, and plotted their diameters against a number of silk line diameters. The graph below shows the results.

Fig.7: Diameters of Trout and Salmon silk lines compared with modern plastic lines



The X-axis shows the AFTM numbers, the Y-axis the diameters. The old silk lines have been "recalculated" to AFTM numbers following the procedure outlined above. The plastic lines comprise floating lines from Scientific Anglers, Cortland, Hardy, Orvis, Rio and Jenzi. The diameters vary a bit, very likely due to different materials. A linear trend curve is included. Also included are the diameters of three Cortland 444 Sylk™ lines, WF 5 and 6 and DT 5.

It is quite obvious that all silk lines are much thinner than modern plastic lines. The difference is in the order of 10 to 20 percent, which is something like one or two line sizes. Sylk™ lines are not dramatically thinner than "normal" synthetic lines.

Concluding remarks:

When selecting a line for an old bamboo rod (or a newly made copy of it, for that matter), with a line designation of, say, HEH written on the shaft, a modern, synthetic AFTM 5 line *may* be the correct one, but not necessarily. Silk lines differ significantly in their behaviour from plastic lines, due to the different material and its inherent properties (elasticity, specific weight) and due to the much thinner diameter, which is on the order of one or two line numbers and which results in a substantial reduction of air-resistance. The silk line/rod system reacts more quickly and subtly to any force applied by the casting hand. It loads much more easily. Air resistance plays a big role given the quite high speeds a line can achieve. Tight loops are important, too. With many casters, a "hissing" of the line in the air can be heard when overpowering a cast. A crack like that from a bullwhip is sometimes heard, usually with the fly disappearing, which is nothing but a sonic boom (the speed of sound is 340 m/s = 770 mph). Another advantage of the thin diameter is its gentle landing on the water, with very little splash.

Plastic lines with their larger diameters need a more powerful rod, and also casting stroke, to drive them through the air. The difference in casting behaviour, silk versus plastic, can be somewhat "strange" to a silk-newbie.

Bamboo rods were in fact developed by the Old Masters during the age of silk lines. Many of the time-proven tapers of Dickerson, Leonard, Payne, and others are indeed best suited to silk lines. Today's rod makers often adjust their tapers to the kinetic properties of synthetic lines.

But, just as plastic lines of the same weight designations from different producers are different in their casting-behaviour (stiff, soft), so are silk lines, whether old, refinished or new (tight or loose braid, different dressings).

I can only repeat what has been preached for decades, indeed for a century: Try out! The correct line for a rod (and the angler) is not always what is printed on the rod or in catalogues. Some fish in small brooks only, with no more than 5 or 6 yards outside the top guide, leader included. They should use a line one or two or even three sizes larger. Others fish in lakes or big rivers with 15 or 20 yards line out and airborne. They might want to try a size or two smaller. This is true for both silk and plastic lines.

> Once more H.P. Wells (1901): "Another thing must be taken into consideration. The load upon a rod varies, of course, with the length of line cast. Therefore, for any given rod, the best size of line is a matter of compromise. Taking all these things into consideration, if we say that the line best fits a rod with which one can cast thirty-five or forty feet most easily, we shall have a very fair working rule."

One more thing should be kept in mind:

At the time silk lines were standard, the leaders were of silk as well. "Silkworm gut" is a substance prepared from the contents of the silk glands of the larvae (commonly called Chinese silk worm) of a species of Asian moth (*Bombyx mori*). The Spanish town of Murcia, capital of the province of the same name in the south-east of Spain, became the world's great center for the manufacture of silk gut leaders. At peak production, Spain turned out 90 million strands of gut each year (J.H. Keene mentions a crop of 32,500,000 in 1884, quoting from the annual Gut Report). All major fishing-tackle producers had their agencies set up in Murcia.

Gut was marketed in 10 diameters, from 0.56 mm/0.022 in. to 0.25 mm/0.01 in. in "natural drawn" (actually drawn with the fingers), and in 7 additional diameters, from 0.23 mm/0.009 in. to 0.12 mm/0.0048 in. as "drawn gut" (drawn through the holes of a template; a gauge). The diameter designation followed -you guessed it- the British Imperial Standard Wire Gauge. Later a slightly different system was established in the US, the **"NAACC official standard table of leader material calibrations with gauge designations, permissible variances, and minimum permissible breaking tests"**.

> panta rhei. Today leader diameter measurements are based on the “rule of eleven”, at least in the "imperial world". Starting with eleven thousandths of an inch diameter (.011”), subtract the “X” from eleven to arrive at the diameter. Example 3X: 11 – 3 = .008 in. diameter. Similarly, for greater diameters than 0X, add .011in. per X. Example 2/0 X: 2 + 11 = .013in. In "metric countries" diameters are measured in fractions of millimeters only.

Tab. 6: British and US gut leader designations and their diameters[3]

England				USA				
Size (trade name)	BIS Wire Gauge No.	BIS Wire Gauge Diameter (in)	BIS Wire Gauge Diameter (mm)	NAACC Size (designation)	Nominal Diameter (in)	Nominal Diameter (mm)	Minimum Permissible Breaking Test (pounds)	Minimum Permissible Breaking Test (approx. kg)
7x	40	0.0048	0.12	7x	0.0045	0.11	1/4	0.11
6x	39	0.0052	0.13	6x	0.0050	0.13	3/8	0.17
5x	38	0.0060	0.15	5x	0.0055	0.14	1/2	0.23
4x	37	0.0068	0.17	4x	0.0060	0.15	5/8	0.28
3x	36	0.0076	0.19	3x	0.0070	0.18	3/4	0.34
2x	35	0.0084	0.21	2x	0.0080	0.20	1	0.45
1x (refinucha)	34	0.0092	0.23	1x	0.0090	0.23	1 1/2	0.68
refina	33	0.0100	0.25	0x	0.0100	0.25	2	0.91
fina	32	0.0108	0.27	10/5	0.0110	0.28	2 1/2	1.13
regular	31	0.0116	0.29	9/5	0.0120	0.30	3	1.36
padron II	30	0.0124	0.31	8/5	0.0130	0.33	3 1/2	1.59
padron I	29	0.0136	0.35	7/5	0.0140	0.36	4	1.81
marana II	28	0.0148	0.38	6/5	0.0150	0.38	4 3/4	2.15
marana I	27	0.0164	0.42	5/5	0.0160	0.41	5 1/2	2.49
imperial	26	0.0180	0.46	4/5	0.0170	0.43	6 1/4	2.83
hebra	25	0.0200	0.51	3/5	0.0180	0.46	7 1/2	3.40
royal	24	0.0220	0.56	2/5	0.0190	0.48	8 3/4	3.97
				1/5	0.0200	0.51	10	4.54

"Note:
1. From 7x to 4x the permissible variance in each gauge designation or size is 1/4 thousandths plus or minus. From 4x to 1/5 the permissible variance in each gauge designation or size is 1/2 thousandths plus or minus.
2. Materials gauging over 20 thousandths shall be specified by diameter only, with a tolerance of 1/2 thousandths plus or minus.
3. No minimum permissible breaking test beyond 10 pounds."

Actual breaking strengths of quality gut are much higher; at least twice the above required minimum values. Gut was marketed in lengths of 15 to 16 inches (very rarely 20 in) and in three qualities: Selecta (the best), Superior and Estriada (sometimes even in five qualities: Natural Selecta, Selecta, Natural Superior, Superior, Estriada).Typical trout leaders were tapered from 7/5 to 1x ("stout") or from 8/5 to 4x ("extra fine") and came in lengths of 2.5 or 3 yards. For salmon and sea-trout fishing the stouter calibrations were used, also three strands twisted together with a "gut twisting engine". The leaders had to be soaked in water prior to putting them to use, to soften them. They became just as supple as the silk lines and had the same specific weight, of course. Greasing them with the same substances as silk lines made them float; rubbing them with "Fuller's Earth" made them sink. Often they were stained: green with tomato leaves, brown with tea or coffee, blue-grey with ink, neutral grey ("London smoke") with walnut leaves and soot, and many more colours/brews.

Fly fishers relied on silk long before they fished with drawn gut and braided lines, namely in the creation of the fly itself, both for binding feathers to a hook and for bodies and heads of flies. The story of silk as fly-tying material begins with texts created long before Izaak Walton, Charles Cotton, and their contemporaries.

The first mention of silkworm gut being sold in Great Britain was in 1722 in an advertisement issued by William Browne, tackle-dealer in London: "... At the same place, all Gentlemen may be satisfied with the best Silk Worm Gut, newly come over."

In angling literature silkworm gut is first mentioned by James Saunders, Esquire, of Newton-Awberry, in his book: "The compleat fisherman. Being a large and particular account of all the several ways of fishing now practised in Europe, with abundance of curious secrets and niceties in the art of fishing, as well in the sea, as in lakes, meers, ponds, rivers or brooklets; whether by darts, spears, harpoons, nets, hook and line, or any other way whatsoever. More particularly calculated for the sport of angling with directions for preparing the angle rods, lines, hooks, and baits, proper for every part of the sport respectively; and also for the an-

[3] What the -/5 –designations mean, or what original measure they were derived from I don't know. Inquiries, also with the Secretary of the American Casting Association (ACA), which succeeded the NAACC, provided nothing.

gler's conduct in rightly applying them. Also, an account of all the principal rivers, lakes, &C. in England; and what kinds of fish are more especially found in them. Collected from the best authors, and from the longest experiences of ... “(W. Mears and S. Tooke, London 1724).

Writing of the Swiss and Milanese, he says: "These, they tell us, make a fine and exceedingly strong hair or line, resembling a single hair, which is drawn from the bowels of the silkworm, the glutinous substance of which is such ... that nothing so small of a size can equal it in nature; for it is rather smaller than a single horse-hair ordinarily used in fishing, ... "

Geo. M. Kelson, in "The Salmon Fly" (1895), credits William Hay, member of the House of Commons in 1734 with " ... introducing Silkworm Gut into this country".

Comparing the tip diameters of trout silk lines, usually H = 0.64 mm/0.025 in. or even I = 0.56 mm/0.022 in. and their suppleness with the thick ends of modern, knotless drawn nylon-leaders, you will often find out that the latter are much too stiff. There is no smooth power-transition from line to leader to fly. You are advised, therefore, to tune your terminal tackle, either by using a leader of proper dimension and/or elasticity or by cutting back (shortening) the tip of the fly line to thicker calibrations. The newly offered braided or "furled" silk leaders are probably not a bad choice.

"Hair, especially the white, is capital stuff for tight line fishing. It is elastic, which gut is not, and if it be taken from a live stallion in good condition, very strong and serviceable. Get it at a violin bow maker's if you cannot find a live stallion of suitable colour." John Harrington Keene: "The Practical Fisherman" (1881) p.396

Selected literature:

Lothar H.H. Martin: **"The History of Silkworm Gut"** The American Fly Fisher, Fall 1991, 1993, pp. 3-7
John Mundt: **"Silk Fly Line Manufacturing: A Brief History"** The American Fly Fisher, Fall 1991, 1993, pp. 8-13
David R. Klausmeyer: **"Smooth as Silk"** The American Fly Fisher, Fall 1991, 1993, pp.12-13
Richard C. Hoffmann: **"The Oldest Silk in Fly Fishing"** The American Fly Fisher, Winter 1993, pp. 16-19
Luis Marden: **"Spain’s Silkworm Gut"** National Geographic, July 1951, pp. 100-108.
The Pilot Gut Company: **"The Story of Silkworm Gut"** 71 pages, n.d.
Victor R. Johnson, jr.: **"America's Fly Lines"**, EP Press 2003, ISBN 0-9740531-0-4

Information available in the internet:

http://www.overmywaders.com/index.php?home
http://www.overmywaders.com/index.php?silk
http://www.overmywaders.com/index.php?cleaningsilk
http://www.flyfishinghistory.com/refinishing_old_silk_lines.htm
http://www.flyfishinghistory.com/silkworm.htm#

Other sources include angling books from a hundred years ago and old catalogues of manufacturers.

My sincere thanks go to Len Safhay for taking the trouble to read through the paper and improving my English.

Finally, a few photos:

An old silk line, totally stripped of varnish and impregnation. The yellowish hue results from minute residues of the old impregnation between the individual silk fibers. It should be white. The braid is clearly seen.

HDH (= approx. DT 6)

A well cleaned Cortland line, of brown colour

HEH (=approx. DT 5)

Two cleaned lines, of olive colour.
The top one is of square cross section, the bottom one round. The two different braiding-patterns are clearly distinguished.

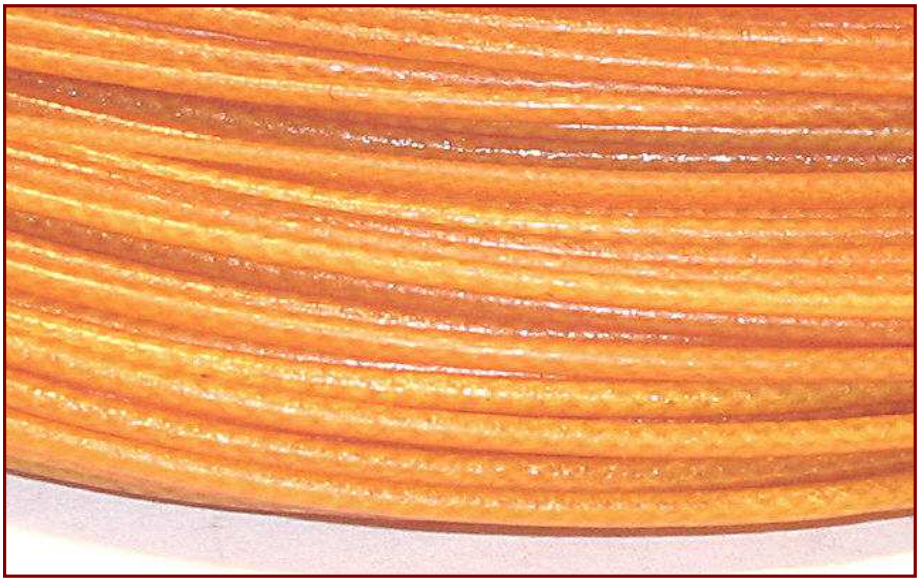
top HEH (= approx. DT 5)
bottom HDH (= approx. DT 6)

An old line, "natural straw", uncleaned. The impregnation has the consistency of honey and the line is stiff. It must be cleaned and refinished. The tiny "holes" or interstices in the braid are not properly filled with dressing. This line would not "shoot" well and eventually cut grooves into the guides.

HDH (= approx. DT 6)

An old Hardy line, uncleaned. Here, too, the interstices in the braid are not filled with dressing. The line should be bottle-green, but the aged dressing -dark brown but not sticky- camouflages the original colour. The line is all but brownish-black.

Corona No. 8, (= approx. DT 9)



A 15+ year old genuine Phoenix line, produced by Noell Buxton. The impregnation has darkened somewhat, but is not sticky. The line has a very smooth surface. It is unfished, still in the box.

DT 5 "DCS"

A renovated Thebault. The line was little used and too stiff for the owner. It was completely cleaned and built-up from scratch, much suppler than before.

WF 5

A renovated Milwards, green. The colour has faded somewhat in places, possibly due to UV-light.

HEH (= approx. DT 5)

A renovated salmon line of unknown make. It sports a spiral in the braid: one of the threads is dyed black.
A WF-line with the following specifications:

3 m parallel tip 0.92 mm,
3.5 m front taper,
9.5 m parallel body 1.62 mm,
4 m back taper,
34 m running line 0.95 mm.
Total length 53 meters/58 yards
Total weight 53.5 grams/826 grains
Weight 20 m 38 grams/586 grains
A tournament line?

A renovated Ashaway Torpedo Head Nylon line. The line is coloured, in segments, green, amber, brown and red.

F2AG (= approx. WF 10)

Carefully frayed ends of two silk lines.

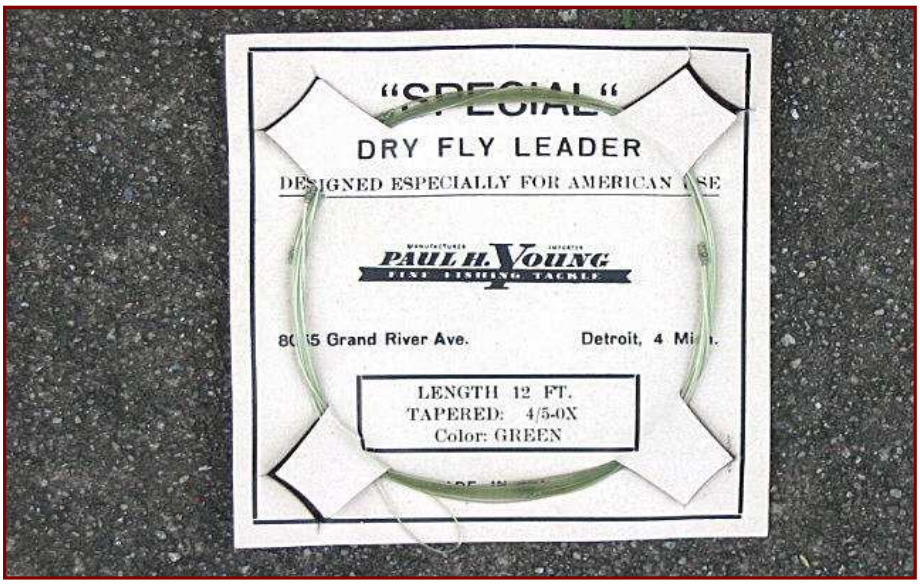
Left: "Ashaway Crandall's American Finish", Level C, 40 yards.
An 8 thread-braid (eight-plait), dyed brown, braided around a core of three twisted undyed threads.

Right: "Hardy Corona" No. 8, (~ DT 9), 35 yards.
It is green, and the threads are only dyed at their outermost "surfaces", the inner parts remaining yellowish/untreated. It has been dyed after braiding.

At left a Hardy gut leader, dyed dark green, 3 yards long. It is built up of 11 strands and tapers from 8/5 to 2X (0.33 to 0.20 mm).

At right gut strands, "natural drawn, selecta" of 0.31 and 0.46 mm (padron 2nd and imperial).

Below the gut, a very early nylon-leader, made of "Platil Strong", tapered (knotted) in five sections from 0.46 to 0.22 mm.



"Special" dry fly leader of "highest grade Spanish Silk-worm gut, fast tapered", sold by Paul H. Young Co ($ 1.95 in 1956).

12 feet long, dyed "light mist green" and tapered ("barrel knots throughout") from 4/5 to 0X (0.43 – 0.25 mm).

At the bottom, covered by the gut "Made in Spain".

Epilogue

Isaak Walton: "The Compleat Angler", 1653
Chapter XXI: Directions for making of a line, and for the colouring of both rod and line

Piscator: ... But first for your Line. First note, that you are to take care that your hair be round and clear, and free from galls, or scabs, or frets; for a well-chosen, even, clear, round hair, of a kind of glass-colour, will prove as strong as three uneven scabby hairs that are ill-chosen, and full of galls or unevenness. You shall seldom find a black hair but it is round, but many white are flat and uneven; therefore, if you get a lock of right, round, clear, glass-colour hair, make much of it.

And for making your line, observe this rule: first, let your hair be clean washed ere you go about to twist it; and then choose not only the clearest hair for it, but hairs that be of an equal bigness, for such do usually stretch all together, and break all together, which hairs of an unequal bigness never do, but break singly, and so deceive the angler that trusts to them.

When you have twisted your links, lay them in water for a quarter of an hour at least, and then twist them over again before you tie them into a line; for those that do not so shall usually find their line to have a hair or two shrink, and be shorter than the rest, at the first fishing with it, which is so much of the strength of the line lost for want of first watering it, and then re-twisting it; and this is most visible in a seven-hair line, one of those which hath always a black hair in the middle.

And for dyeing of your hairs, do it thus: take a pint of strong ale, half a pound of soot, and a little quantity of the juice of walnut-tree leaves, and an equal quantity of alum: put these together into a pot, pan, or pipkin, and boil them half an hour; and having so done, let it cool; and being cold, put your hair into it, and there let it lie; it will turn your hair to be a kind of water or glass colour, or greenish; and the longer you let it lie, the deeper coloured it will be. You might be taught to make many other colours, but it is to little purpose; for doubtless the water-colour or glass-coloured hair is the most choice and most useful for an angler, but let it not be too green.

But if you desire to colour hair greener, then do It thus: take a quart of small ale, half a pound of alum; then put these into a pan or pipkin, and your hair into it with them; then put it upon a fire, and let it boil softly for half an hour; and then take out your hair, and let it dry; and having so done, then take a pottle of water, and put into it two handfuls of marigolds, and cover it with a tile or what you think fit, and set it again on the fire, where it is to boil again softly for half an hour, about which time the scum will turn yellow; then put into it half a pound of copperas, beaten small, and with it the hair that you intend to colour; then let the hair be boiled softly till half the liquor be wasted, and then let it cool three or four hours, with your hair in it; and you are to observe that the more copperas you put into it, the greener it will be; but doubtless the pale green is best. But if you desire yellow hair, which is only good when the weeds rot, then put in more marigolds; and abate most of the copperas, or leave it quite out, and take a little verdigris instead of it.

This for colouring your hair.