

Cotton Technical Brief



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YARN NUMBERING SYSTEMS

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YARN NUMBERING SYSTEMS

INTRODUCTION

Textiles are often sold on a weight basis and consequently it is natural to express the size of "thickness" of a yarn in terms of weight (or mass). There are two basic ways in which this may be done. These are: (a) by saying how much a given length of yarn weighs, or (b) by saying what length of yarn one would have in a given weight. Generally these are known as the direct and indirect systems of yarn numbering, respectively. In other words:

$$\text{Direct yarn number} = \frac{\text{Weight(or mass)}}{\text{Length}}$$

$$\text{Indirect yarn number} = \frac{\text{Length}}{\text{Weight(or mass)}}$$

It will be noted that one is the inverse of the other. In the first case, the number gets larger as the yarn or strand gets coarser. In the second case, the number gets smaller as the yarn or strand gets coarser.

Each system has its advantages and disadvantages and each has found areas in which, by custom, it is used. It so happens that because long, thin strands are usually involved, the length figures are usually large and the weight figures are small. Consequently, the yarn numbers would get impossibly large or impossibly small unless special units are used. The following paragraphs will explain a selection of the most important sets of units used. A summary is listed in Table 1 on page 6.

DIRECT SYSTEMS

The technical name used to describe the yarn size in the direct system is linear density,* and this is always expressed in terms of weight/unit length. In commerce, the technical name is used less frequently than in the fiber industry or the scientific community. Often the name of the particular unit, such as denier or tex is used instead. Sometimes the term "yarn number" is used, but this is confusing unless the system is quoted.

With the usual range of linear densities found in yarns, one pound of yarn if stretched out straight could extend up to 20 miles in length. Clearly if one were to express the linear density in lb/yd, the numbers would be impossibly small and cumbersome to use. Since scientists tend to use the metric system [grams (g) and meters (m) for weight and length, respectively] one could consider g/m as a unit, but in this case, it turns out that the number is too large to be handled conveniently.

In practice there are two major subsections, which refer to yarn. In one case, the logically minded scientists have chosen a length unit of 1000 meters, whereas the technologists have chosen 9000 meters. The reason for this latter choice is obscure.

*This should not be confused with volumetric density as used in physics.

The scientific subsystem uses the unit "tex," where 1 tex is the weight in g of 1000 meters (1 km) of yarn and the number gets bigger as the yarn gets fatter. Thus, a 50 tex yarn weighs 50 g for every kilometer of yarn. The normal metric prefixes of kilo, deci, etc., can also be applied to the unit tex. Hence 1 decitex is 1/10 tex and 1 kilotex = 1000 tex.

The fiber industry tends to use the unit "denier" where 1 denier is the weight in g of 9000 meters of yarn. Thus a 450 denier yarn weighs 450 g for every 9000 meters. A moment's reflection will show that the two examples given refer to the same yarn size. Denier is very often used to describe the size of the fiber; hence, a 1½ denier filament weighs 1½ g per 9000 m of that filament. In passing it might be noted that if the 450 denier yarn is made up of 1½ denier filaments, there will be $450/1\frac{1}{2} = 300$ filaments making up that yarn.

As will be shown later, there are intermediate products, such as sliver, to which the direct system of measurement can be applied. A sliver is a rope-like material and a typical linear density (or "sliver weight") is 50 grains/yard. (A grain is 1/7000 lb. and care should be taken when handwriting the units to distinguish clearly between grain and gram.)

In this bulletin, the symbol "n" will be used to denote linear density, and in every case, the appropriate units should be quoted.

INDIRECT SYSTEMS

It will be remembered that the indirect system is in terms of length per unit weight. Once again, there has to be special units, but there is a large variety of systems which are a legacy of the ancient crafts, and there is no discernible logic in the choice of units. Generally, all the subsystems in this category are referred to as yarn count or yarn number, and it is necessary to specify the subsystem if confusion is to be avoided. It is normal to specify the yarn count in hanks/lb where a hank contains a specified length of yarn. Unfortunately, each of the subsystems specifies a different length.

In cotton processing technology (and those technologies which have evolved from that technology), the units developed in England during the industrial revolution are still used in the USA. In this case, a hank is specified as containing 840 yds* of yarn. Thus, if the count of a singles yarn is 20 hanks/lb. (usually written as 20s or 20/1), there will be 20 x 840 yards in a pound of yarn. The symbol used in this bulletin will be N_e where the subscript refers to "English" and distinguishes it from N_m , which refers to the metric count (meters/gram). In the case of long staple yarns, whose technology is derived from one of the processes for making yarn out of wool, a hank is often defined as 560 yds. of yarn, and in this case, the symbol N_w will be used to describe count. There are many others, and a list of some specified hank lengths is given in Table 1.

With the indirect system, the number gets larger as the yarn gets finer. In the English cotton system, a 4s yarn is very coarse whereas 40s yarn is fine.

Examples:

Q. How many yards of yarn are there in 1 lb. of 24s (N_e) yarn?

A. In 1 lb. of yarn, there are $840 \times 24 = 20,160$ yds.

*Note: 840 is divisible by 1, 2, 3, 4, 5, 6, 7 and 8.

Q. If there are 20,160 yds in 1 lb. of yarn, what is the worsted count?

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A. $\frac{L}{W} = 560 \times N_w$ where L = length in yds and W = weight in lbs.

$$\therefore N_w = \frac{L}{560W} = \frac{20160}{560 \times 1} = 36 \text{ hanks/lb. or } N_w = 36s$$

[From the above, it will be realized that N_w is 50% larger than N_e for the same yarn.]

Q. If $N_e = 24s$, what is the linear density in tex?

A. This is a conversion from an indirect system to a direct system; therefore, one is inversely proportional to the other, i.e.,

$$n' \propto \frac{1}{N_e}$$

$$n' = \frac{1}{840N_e} \frac{\cancel{\text{hank}}}{\text{yd.}} \cdot \frac{\text{lb.}}{\cancel{\text{hank}}}$$

There are approximately 1.09 yds in 1 meter and 454 grams in a pound.

$$\begin{aligned} \therefore n'' &= \left(\frac{1}{840N_e} \right) \frac{\cancel{\text{lb.}}}{\cancel{\text{yd.}}} \times 454 \frac{\text{gram}}{\cancel{\text{lb.}}} \times 1.09 \frac{\cancel{\text{yd.}}}{\text{meter}} \\ &= \frac{454 \times 1.09}{840N_e} \text{ gram/meter} \end{aligned}$$

Since the linear density in tex is the number of grams in a kilometer of yarn

$$\begin{aligned} n &= 1000 \frac{\cancel{\text{meter}}}{\text{kilometer}} \times n'' \frac{\text{gram}}{\cancel{\text{meter}}} \\ &\cong \frac{1000 \times 454 \times 1.09}{840N_e} \text{ tex} \\ &\cong \frac{591}{N_e} \text{ tex} \end{aligned}$$

Since $N_e = 24$, $n = 23.6$ tex

Q. If a 120 yd. skein weighs 40 grains, what is the cotton count?

$$\begin{aligned} \text{A. } N_e &= \frac{L}{840W} N_e \text{ where L = length in yds and W = weight in pounds} \\ &= 120 \cancel{\text{yd.}} \times \frac{1}{840} \frac{\text{hank}}{\cancel{\text{yd.}}} \times 7000 \frac{\cancel{\text{grain}}}{\text{lb.}} \times \frac{1}{40 \cancel{\text{grain}}} = \frac{1000}{40} \frac{\text{hank}}{\text{lb.}} \\ &= 25 \text{ hank/lb.} \end{aligned}$$

3 e: 120 yd. skeins are commonly used because it gives the simple formula:

$$N_e = \frac{1000}{W_1} \text{ where } W_1 = \text{weight in grains.}$$

CONVERSION

In normal practice, it is unnecessary to go through such a calculation each time a conversion is required, and generally a conversion factor can be used (see Table 2). In the case of converting from one direct subsystem to another, one merely multiplies the known linear density by the conversion factor to get it into different counts, similarly, when converting from one indirect subsystem to another. When converting from indirect to direct, or vice versa, then the factor must be divided by the known quantity. In symbols, for example:

$$n = \frac{591}{N_e} \text{ tex}$$

PLIED YARNS

It is possible to make up the linear density of a yarn by twisting together two or more finer yarns. The process is called plying, and the yarns are called plied yarns. The process makes the yarns more flexible and durable but adds to the cost.

To show that a yarn is plied, it is normal to write both the yarn number and the number of plies separated by a slash. In some systems, the quote yarn number is that of each component, and in others, it refers to the whole assembly. Here the former system will be used with the yarn number quoted first. Thus a 100 den/3 would mean that 3 plies of 100 denier yarns were twisted together to give a yarn whose equivalent linear density would be approximately 300 denier (the twisting causes a slight effect). Thus with a direct system, one adds together the individual linear densities to arrive at the total.

With an indirect system, the problem is a little more complicated. Ignoring twist effects, imagine a number of yarns lying side by side, each being of the same length (L) yards. If the weights of the strands are $W_1, W_2, W_3, \text{ etc.}$, then the total weight (W_T) = $W_1 + W_2 + W_3, \text{ etc.}$, but

$$W_1 = \frac{L}{840N_{e1}}, \quad W_2 = \frac{L}{840N_{e2}}, \text{ etc.}$$

$$W_T = \frac{L}{840} \left\{ \frac{1}{N_{e1}} + \frac{1}{N_{e2}} + \frac{1}{N_{e3}} + \text{ etc.} \right\}$$

where $N_{e1}, N_{e2}, N_{e3}, \text{ etc.}$, are the yarn counts of the individual yarns. The equivalent count of the ply is:

$$N_{eT} = \frac{L}{840W_T} \quad \therefore \quad \frac{1}{N_{eT}} = \frac{840}{L} W_T$$

and

$$\frac{1}{N_{eT}} = \frac{1}{N_{e1}} + \frac{1}{N_{e2}} + \frac{1}{N_{e3}} + \text{etc.}$$

For example, if four 40s yarns are plied together and twist effects are ignored,

$$\frac{1}{N_{eT}} = \frac{1}{40} + \frac{1}{40} + \frac{1}{40} + \frac{1}{40}$$

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from which it follows that $N_{eT} = 10$ hanks/lb. Notice how the equivalent yarn number is smaller than any of the yarn numbers of the component yarns.

YARN DIAMETER

It might be thought that the obvious way to describe a yarn would be by its diameter, but there are difficulties with this approach. A textile yarn by its very nature has to be soft and can squash; therefore, it rarely remains round in fabric form. Different fibers are used in all sorts of combinations, and it would be a complex matter to calculate weights because of the physical differences in the fibers. Nevertheless, it is helpful at times to have an idea of yarn diameter. For example, the diameter helps determine how closely the yarns can be packed to make a fabric or how well a given yarn will cover* in a given fabric. The linear density of a yarn is equal to the product of the number of fibers and the average linear density of the fibers.

$$\text{i.e., } n_y = m \times n_f$$

where n_y = linear density of yarn, n_f = linear density of fiber, and m = number of fibers in the cross section.

Assume that the fibers are evenly spread throughout the cross section at a rate of b fibers per square inch. A yarn of diameter " d " inches has a cross-sectional area of $\pi d^2/4$ sq. in. and contains $(\pi d^2/4) \cdot b$ fibers [i.e., $m = (\pi d^2/4) \cdot b$]. Substitute for m in the above equation and rearrange

$$d = \sqrt{\frac{n_y}{n_f} \cdot \frac{4}{b\pi}}$$

Thus, for a given fiber, $d \propto \sqrt{n_y}$. Also, referring back, it will be realized that the diameter is also inversely proportional to the square root of the yarn count (i.e., $d \propto \frac{1}{\sqrt{N_e}}$).

*Cover is a term to describe how tightly packed the yarns are in a fabric. The extremes can be imagined by considering a net curtain and a bed sheet.

Table 1 — Yarn Numbering Systems

	Direct		Indirect		Other		
	Name	Units	Name	Units	Name	Units	
FIBER							
Cotton	micronaire	micrograms/in. milligrams/cm			diameter	microns	
Wool	denier	grams/9000 meters					
Man-made							
INTERMEDIATE PRODUCTS							
Picker lap	lap "weight"	ounces/yd or pounds/lap*					
Sliver	} sliver "weight" or kilotex**	grains/yd grams/meter					
Top							
Comber lap							
Comber ball							
Roving (cotton)		grain/yd**	hank roving N_c	hanks/lb			
YARNS							
Man-made yarns	denier	grams/9000 meters					
All yarns (scientific)	tex	grams/1000 meters					
Cotton & blend yarns							
Worsted yarns			English cotton count N_e	hanks/lb (hank = 840 yds)			
			Worsted count N_w	hanks/lb (hank = 560 yds)			
Woolen yarns			Woolen run N_{wr}	hanks/lb (hank = 1600 yds)			
All yarns (European)			Metric count N_m	meter/gram			

* For known lap length.
** Infrequently in USA.

Table 2 – Conversion Factors

	Direct		Indirect		
	To Tex n_t	To Denier n_d	To Cotton Count N_e	To Metric Count N_m	To Worsted Count N_w
From Tex (n_t)		$9 \times n_t$	$590.5 \div n_t$	$1000 \div n_t$	$885.8 \div n_t$
From Denier (n_d)	$0.111 \times n_d$		$5315 \div n_d$	$9000 \div n_d$	$7972 \div n_d$
From Cotton Count (N_e)	$590.5 \div N_e$	$5315 \div N_e$		$1.693 \times N_e$	$1.50 \times N_e$
From Metric Count (N_m)	$1000 \div N_m$	$9000 \div N_m$	$0.5905 \times N_m$		$0.8858 N_m$
From Worsted Count (N_w)	$885.8 \div N_w$	$7972 \div N_w$	$0.6666 \times N_w$	$1.129 \times N_w$	

Note: N_e = English cotton count
 N_m = Metric count
 N_w = Worsted count

n_t = Linear density in tex
 n_d = Linear density in denier

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Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.
- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.
- Computerized fiber management techniques result from in-depth fiber processing research.
- Textile research operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.
- Technical services provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.
- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.
- The Company operates its own center for dyeing and finishing and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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