FIBRE MEASUREMENT

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The accurate and objective measurement of various characteristics of natural fibre is known as "fibre metrology". Measurements are useful in describing the fleece characteristics of any one animal, and can be used to compare the fibre characteristics of animals within the same herd, animals in different herds, or of the same animal at different times. They can be used to compare the progeny of one sire with the progeny of another to assist in formulating breeding strategies. They are used when fleece is sold by description, and processors may use them to predict the performance of pooled fibre during processing.

Care needs to be exercised, however, in making these comparisons, as there are many non-genetic factors which may influence these measurements. Before comparing the characteristics of two fleeces, one needs to take into account the influence of such factors as the sex, age, nutrition, colour, and general health of the alpacas from which the fleeces were taken, the climate in which the fleeces were grown, and whether or not a female was lactating, or a male working as a stud sire. Other considerations should include the length of the fibre sampled, the site from which the fibre was sampled, and the technique used to measure the fibre.

There are many reasons why people choose to own and breed alpacas, but commercially, the alpaca is bred for its ***fleece.*** Two parameters alone will determine the value of an alpaca in producing fleece, and they are ***fineness*** and ***fleece weight.*** Other characteristics, including length, colour, lustre, lack of vegetable matter, uniformity of micron and length, and resistance to break, may all contribute in some small part to the value of a fleece, but it is essentially for fleece weight and fineness that the cheque will be written.

There are many ways to increase fleece weight. If one considers two identical alpacas, one might consider the effect of increasing fibre diameter, leaving all other factors equal. This will have a dramatic effect in increasing fleece weight, as doubling fibre diameter will quadruple fleece weight. Or if we leave fibre diameter the same, we could grow fleece at a faster rate. In this case, doubling growth rate would double fleece weight. We could grow bigger alpacas: but since body weight increases proportionally with volume and fleece weight only with surface area, we would need to almost triple the size of an alpaca to double its fleece weight. Or we could grow ***denser*** alpacas, doubling the hairs per square centimetre to double the fleece weight.

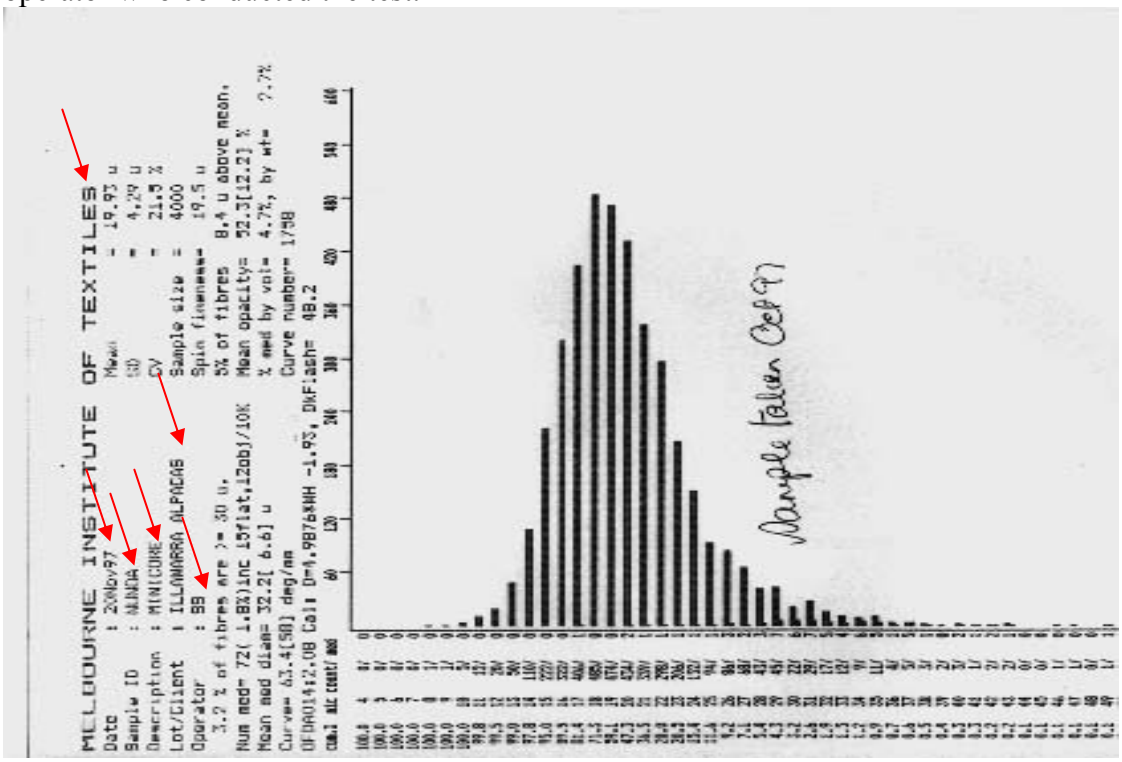
Increasing fibre diameter, whilst having the most dramatic effect on fleece weight, will also have a dramatic but counter-productive effect on fleece value, as stronger fibre is worth considerably less than fine fibre. The risk of breeding for longer fleeces is that the annual rate of growth may exceed the maximum specification for premium fibre length, resulting in a downgrading of fleece value if the animal is shorn annually, or incurring the extra expense and inconvenience of more frequent shearings if the fleece is to meet ideal length specifications. Growing bigger alpacas will also result in increased costs, as nutritional requirements are based on body mass, which increases much faster than fleece weight, which is based on surface area.

Only increasing fleece density—usually expressed as the number of follicles per square centimetre—will result in increased fleece weight without penalty.

Having established how best to increase fleece weight, let us turn to the other part of the equation for financial success: fineness. To understand what is meant by fibre fineness, it is necessary to first understand how it is measured. Traditionally, crimp was always regarded as the best indicator of fineness, with a fine crimp reflecting a fine fibre. For much of the 20th century, fibre fineness was measured using microscopes, laboriously measuring individual fibres, using either an optical microscope (where the image was seen by looking down the lens of the microscope) or a projection microscope (where the image is projected, like a slide, onto a screen). As both were slow, and hence expensive, it was for many years accepted that fineness of crimp was a proportional indicator of fineness of fibre. It was only when other means of quickly measuring large numbers of fibres became available that this was recognised to be a fallacy. Initially, devices were designed to measure the obstruction ("impedance") produced by a sample of fibres to a stream of air or sound, and the diameter of the fibres then deduced from the level of impedance they produced. This measurement was inaccurate for medullated (hollow) fibre like that found in many alpacas, however, because the differing mass of medullated and nonmedullated fibres of the same diameter produced different measures of impedance.

This was overcome with the advent of the Optical Fibre Diameter Analyser (OFDA) and the Laserscan, both Australian inventions which can accurately measure medullated and nonmedullated fibres, and can distinguish between them.

In looking at the typical histogram produced by either of these two techniques, one can read off the name of the institution conducting the test, the date of the test, the identity of the sample, the technique used to sample the fibre, the client, and the operator who conducted the test.



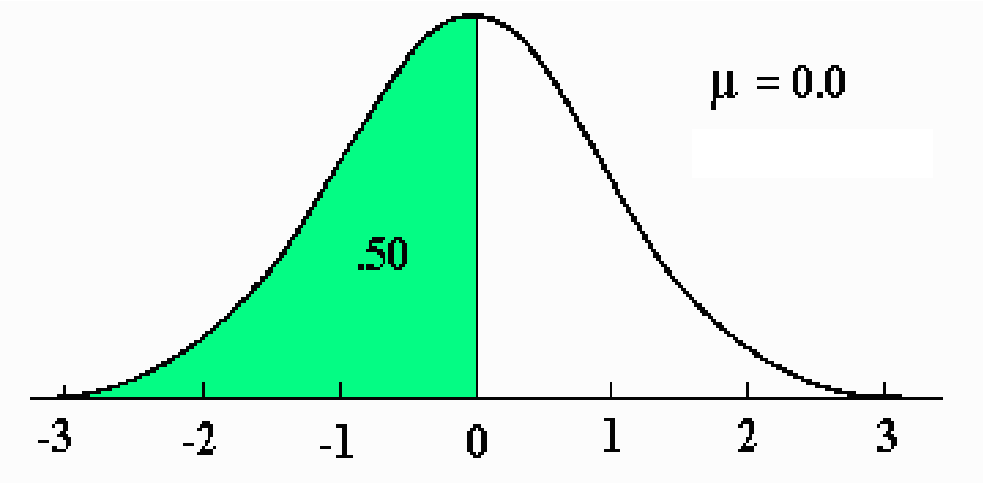
The remaining data refers to the measurement of the fibre sample. The histogram is a graphical representation of all the fibre diameter measurements taken in any one sample, and then sorted out into columns recording the number (frequency) of measurements (observations) for each successive diameter value (score).

If one measures a single feature (eg. height, weight, age) in every member of a given population, and then records the score for that feature (usually on the horizontal axis, in ascending order) plotted against the frequency with which that score was observed (usually plotted on the vertical axis, in ascending order), one will get what is known as a ***frequency/distribution curve.*** In a graph where the frequency distribution is even and symmetrical around a central score, the curve is known as a ***normal curve.***

The normal curve is a theoretical, "ideal" curve, where the average score (mean), most commonly occurring score (mode), and the score above which 50% of all scores fall, and below which the other 50% of scores fall (median), are all one and the same. The shape of the curve is symmetrical around a vertical axis, which is the mean/median/mode score, and the curve looks like a bell on either side of that axis. Hence, the normal curve is also known as a "bell curve". By adding together the recorded frequencies for every score (that is, the number of times a particular value is recorded), the total population of the sample can be calculated. It is helpful to imagine a truckload of bricks, each weighed, and then piled into columns according to the weight of each individual brick. The result would resemble a bell curve, and the height (in bricks) of each column, if added together, would equal the total number of bricks.

Real frequency distribution curves are never "ideal", but are rough approximations to the bell curve.

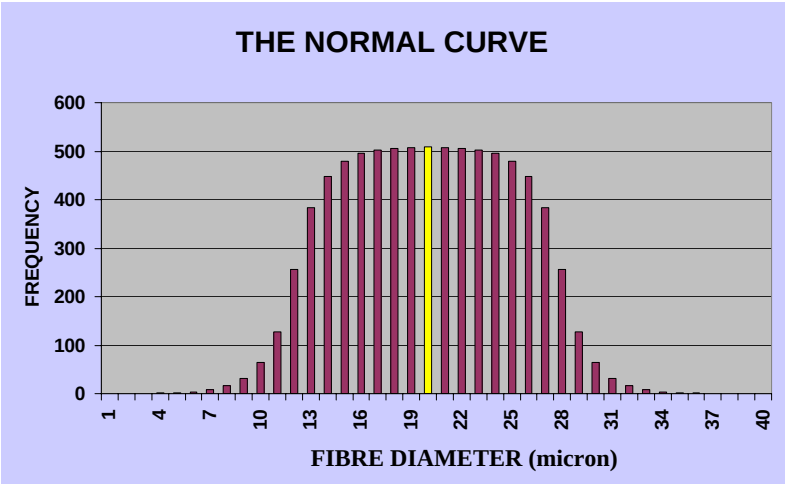
Let us consider for a moment an ideal Normal Curve.



50% of all scores fall below the average (mean) score, indicated here as $\mu = 0$. The other 50% fall above the mean. The total area under the curve, like the piles of bricks, represents 100% of all measurements (or bricks). Similarly, that proportion of the total area which falls under any *segment* of the curve, defined by a range of weights,

represents the percentage of the total number of bricks (or measurements) falling within that range.

The mean is defined as the average score: that is, the total combined value of all the measurements made, divided by the number of readings, eg. the total weight of all the bricks, divided by the number of bricks.

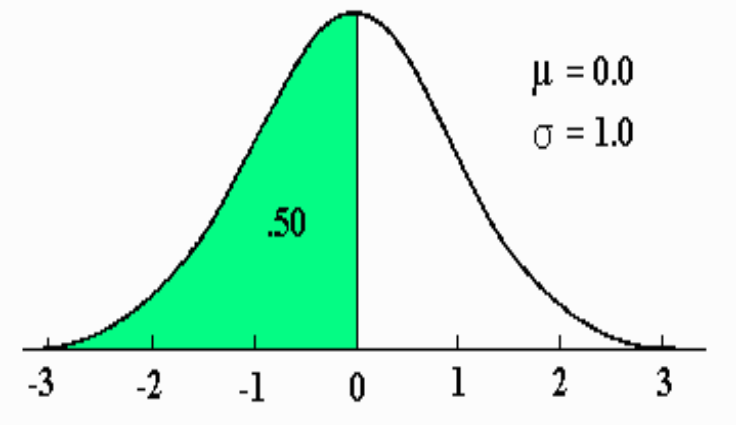


In this idealised normal curve, we have plotted a theoretical frequency/distribution curve for fibre diameter in a fleece sample. It records ascending values for fibre diameter along the horizontal axis, and the frequency of those observations along the vertical axis. It is "ideal" because it is symmetrical, and the mean fibre diameter of 20 microns is also the mode and median score. The histogram tells us that there were just over 500 fibre diameter measurements of 20 microns, and about 250 of 28 microns.

A micron (often abbreviated as µ) is a millionth of a metre. Just as a millimetre is $1/1000^{th}$ of a metre, a micron is $1/1000^{th}$ of a millimetre. Some typical micron measurements would be 400µ for the thickness of a pin, 100µ for the thickness of a sheet of paper, 70µ (human hair), 40µ (guard hair), 30µ (mohair), 25µ (alpaca), 25µ (silk), 25µ (wool), 15µ (superfine wool), 12µ (vicuna), and 11µ (musk ox).

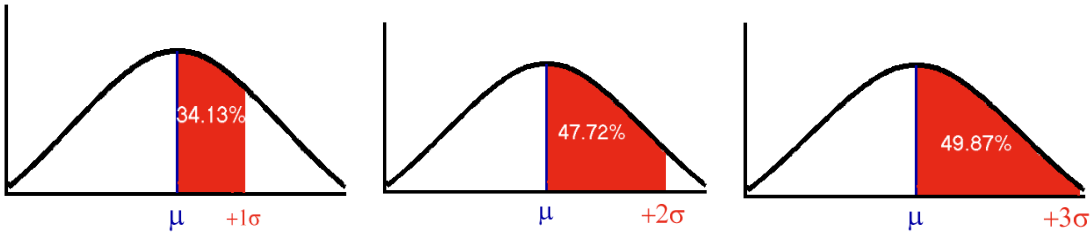
Just as we determined that there is an average score, we can determine the average amount by which *individual* scores vary from the mean. This is called the standard deviation (SD), and is measured in the same units as the mean (eg. microns). The calculation that is used to derive the standard deviation measures the difference between each score and the mean score, squares it (multiplies it by itself) to give a positive figure, adds up all these figures for every score, divides it by the number of scores to get an average, and then takes the square root of that figure to "undo" the effect of squaring it in the first place. So in a histogram with a mean fibre diameter (MFD) of 23µ, and SD of 4µ, the average fibre variation from the mean of 23µ is plus or minus 4µ.

Consider now this normal curve, with mean (normally denoted as μ ["m-yu"]) of 0.0, and SD (normally denoted as σ [sigma]) of 1.0:

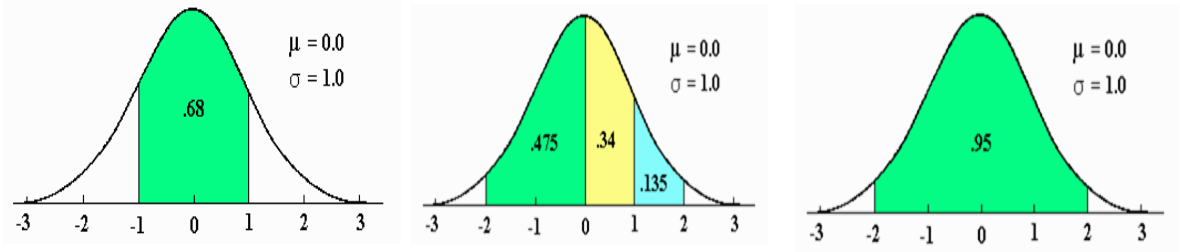


The relationship between the mean and the SD is mathematically defined, and in ***all*** normal (ideal) curves, it can be shown that 34.13% of all scores fall in that segment of the curve defined by the mean and one SD above the mean.

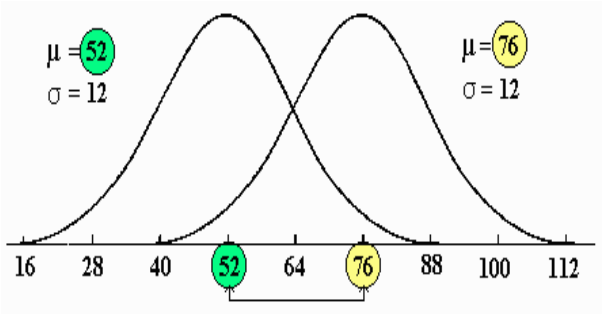
Similarly, 47.72% lie within two SD's above the mean, and 49.87% within three SD's above the mean.



Stated differently, 68% (34.13 x 2) of all scores lie with one SD *either side* of the mean; 95% (47.72 x 2) of all scores lie within two SD's of the mean, and virtually 100% of all scores are within 3 SD's of the mean. Remembering simply the 68% and 95% figures for one and two SD's is all that is required to have a good appreciation of the statistics and probabilities of the normal curve.

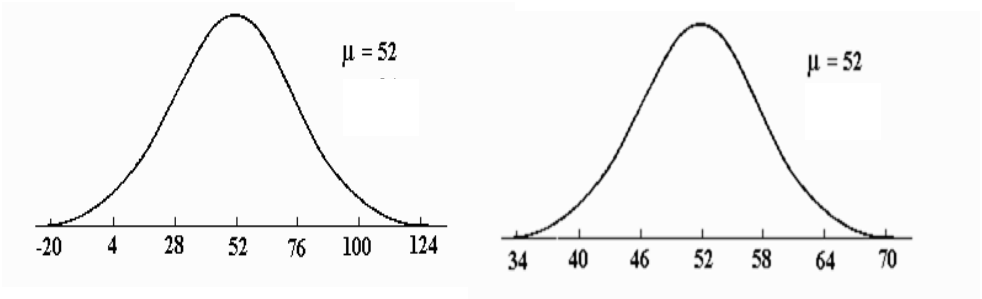


Now we need to consider what the shape of a normal curve tells us. Consider the following two curves:



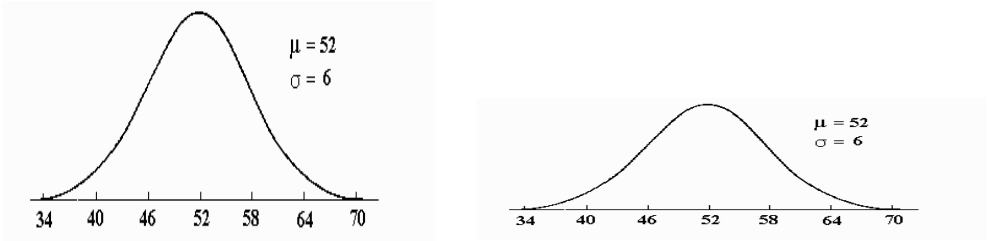
These curves are of identical shape on the same scales: they have the same SD (12), but different means (52 and 76). The second curve is essentially the same as the first curve, but pushed to the right. As the area under both curves is the same, the number of measurements is also the same.

Now consider *these* two curves:

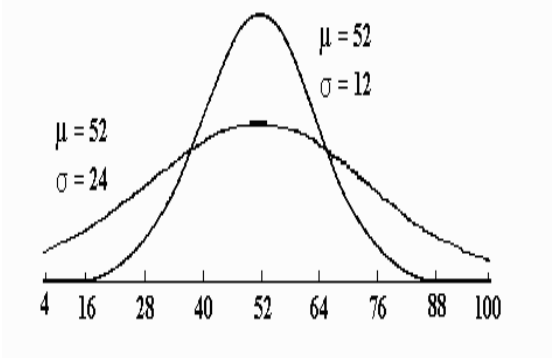


Same shape, same mean, same curve, right? Wrong! Check the scale on the horizontal axis: that accounts for why the SD's are so different: 24 on the left, and 6 on the right.

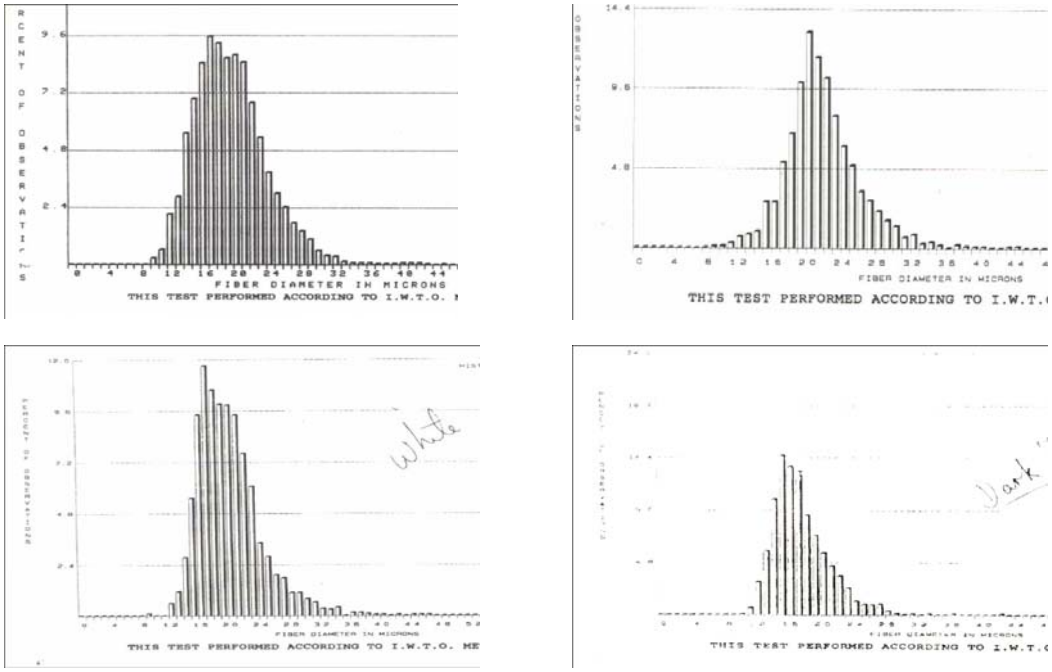
The following two curves are identical! Only the scales differ! So remember to ***check the scale!***



Here's what happens when you change the SD, but not the mean: the curve flattens, because its area (population) is spread out over a wider range, but the axis of symmetry (the mean) remains unchanged.



Now you understand the histogram, consider the following four histograms. You are looking to purchase a stud male, and these are the histograms of fibre diameter associated with four males. Which would you choose?

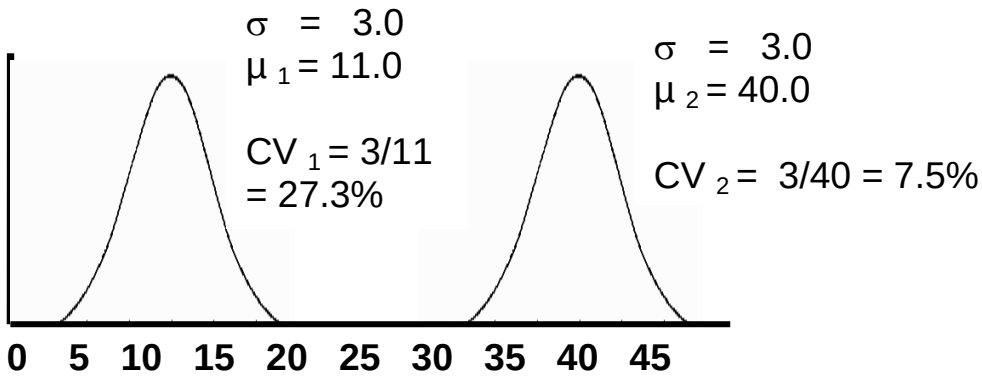


Naturally, since you can't see the scales, you would ask for the MFD and SD, which are respectively 21.6/4.9; 19.5/4.5; 20.0/4.3; and 17.3/3.6. The curves don't seem to show that the last is the best histogram, but that's because the vertical scale is to 9.6 in the first graph, 14.4 in the second, 12 in the third, ***and 24 in the last.***

So we go for the last male, right? Well, only if you are happy that a four year old male should be sold on the basis of his fibre sample taken at eight months. What of the others? Well, #1 is 3 years old, but weighs only 40kgs; #2 is a wether; and #3 is a brown and white fancy. ***Never buy an animal on the basis of his fibre stats alone.***

Moving on now to the **coefficient of variation**. There is an intrinsic problem in comparing the SD's of two animals whose mean microns are poles apart: consider two hypothetical alpacas, one with MFD 11 micron, and the other with MFD 40 micron. Both have a SD of 3 micron. In a fleece with MFD of only 11, that 3 micron either side of the mean represents huge variability in the fleece, whilst the same 3 micron either side of the mean in the 40 micron fleece is actually a very tight and even distribution. So it was decided to represent the SD as a fraction of the mean, expressed as a percentage, and called the ***coefficient of variation.*** This is another way to look at the evenness of the fleece.

$$\mathbf{CV_d = SD / MFD \times 100\%}$$

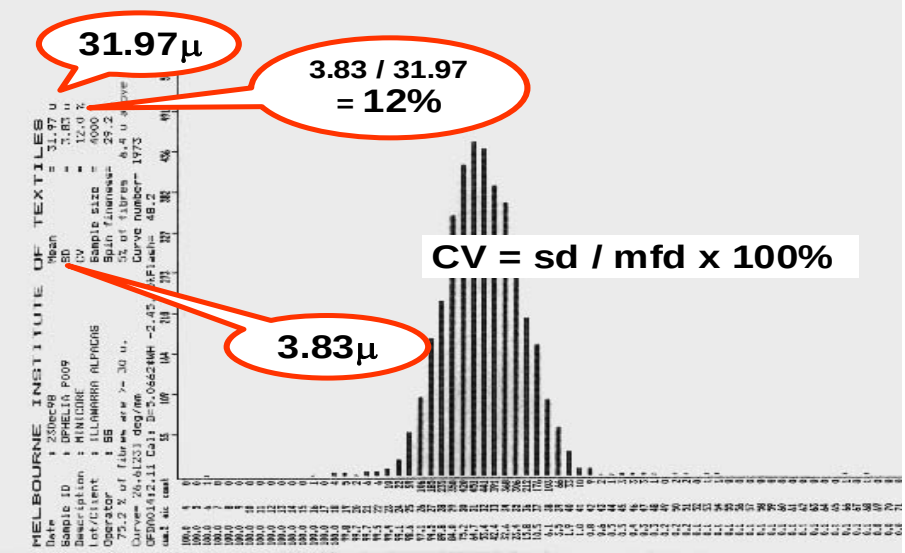


The variation in fibre diameter is seen both between different fibres (interfibre variation) and along the length of individual fibres (intrafibre variation). Variation between fibres is a reflection of the variation that may exist between individual follicles, and the size of the fibres that those follicles produce, and is probably largely ***genetically*** determined. Variation along the length of individual fibres is a reflection of the nutrition and health of the alpaca, and may vary widely with seasonal variations in the availability of feed, the demands of pregnancy and lactation, and periodic illness. Intrafibre variation is largely ***environmental*** in origin, and fibre diameter variation along the length of the fibre is like a diary of the conditions that existed at the time the fibre was produced from the follicle.

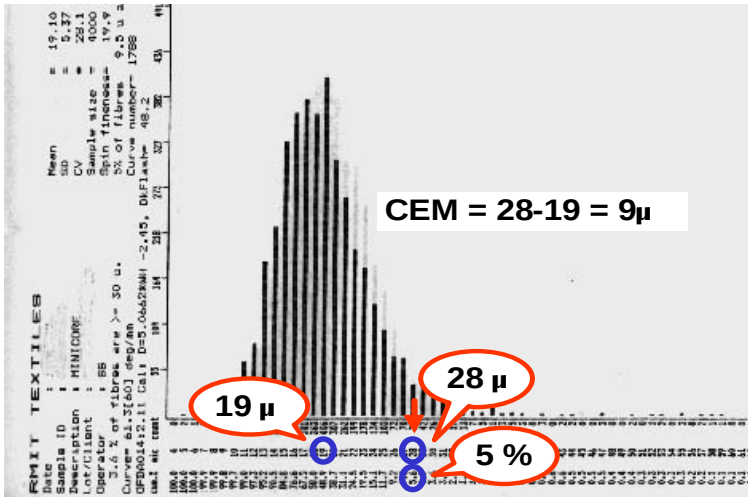
This has some relevance to the way in which the fibre is sampled. In North America, most fibre samples are tested as "butt cuts", in which every fibre in the sample is measured at the same defined distance from the surface of the skin. Each fibre is thus sampled only once, and the resulting histogram is an accurate representation of the fleece at one particular moment, when those fibres were all emerging from the follicles. In Australia, the minicore technique of sampling fibre cuts every fibre in the sample into many small pieces, and then measures a number—usually 4000—of the

snippets to create the histogram. As a result, individual fibres may be measured at many points along the length of the fibre, and the variation represented in the CV therefore reflects both interfibre (genetic) and intrafibre (environmental) variation. In general terms, therefore, fleece sampled by the latter technique may be expected to show higher CV's than those sampled by the former technique.

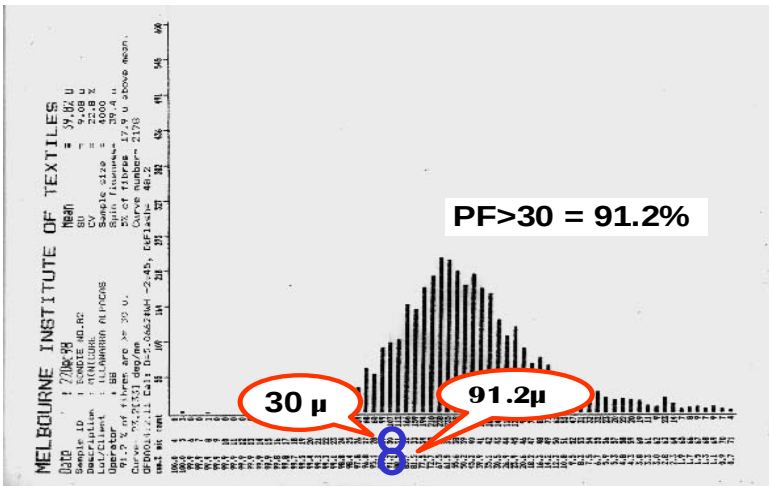
A low CV does not always represent a superior fleece: a high micron, coarse fleece with relatively low variation will exhibit a very low CV:



Now, we move on to **Coarse Edge Micron (CEM)**. It is important to remember that we are not dealing with the ideal *normal* curves in looking at fibre histograms. The "tail" of the fibre histogram represents those coarse fibres that skew the histogram to the right. The CEM tries to put a descriptive handle on the tail by telling us where the tail—the coarsest 5% of fibres—starts. It is defined as the number of microns *above the mean* above which the last 5% of fibres lie. For example, in a histogram where the mean is 19 micron, and 95% of fibres lie at or below 28 microns, the CEM is 9 (28-19 = 9) microns.

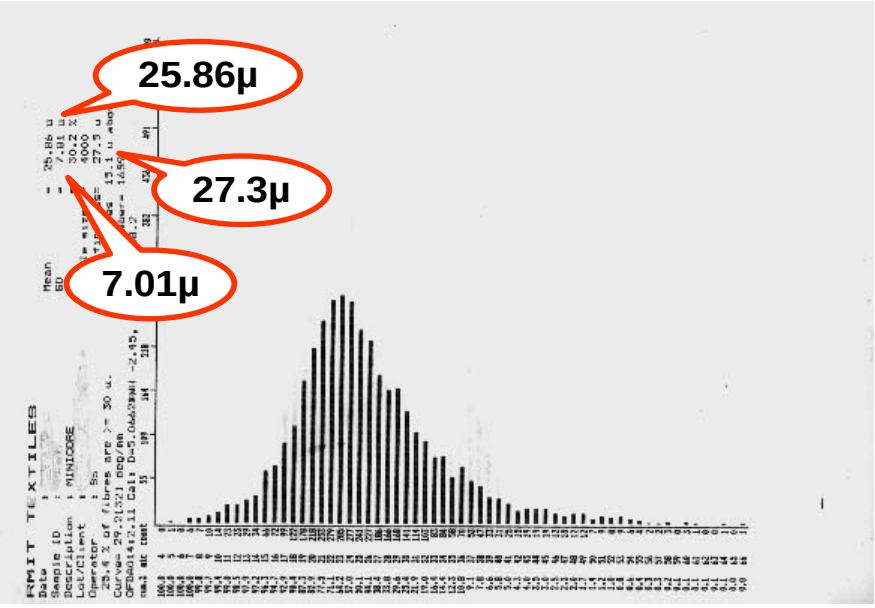


The **Comfort Factor** refers to research done in Australia in the wool industry in the early 80's which found that 90% of people complained of prickliness in woollen products worn next to the skin if the yarn contained >5% of fibres over 30µ. (More recent research has suggested that, for 90% of people to feel *no* discomfort against the skin, the percentage of fibres over 30µ needs to be *under 2%* !) What used to be called "Prickle Factor" referred to that percentage of fibres over 30µ; it has now been changed, and is expressed as the more acceptable term, "Comfort Factor", referring to the percentage of fibres *less than* 30µ. So a comfort factor of 94% (a prickle factor of 6%) in fact means that *over 90%* of people will find a garment made from this fibre to be prickly against the skin. Some comfort! In fairness, these findings have yet to be validated for alpaca fibre.



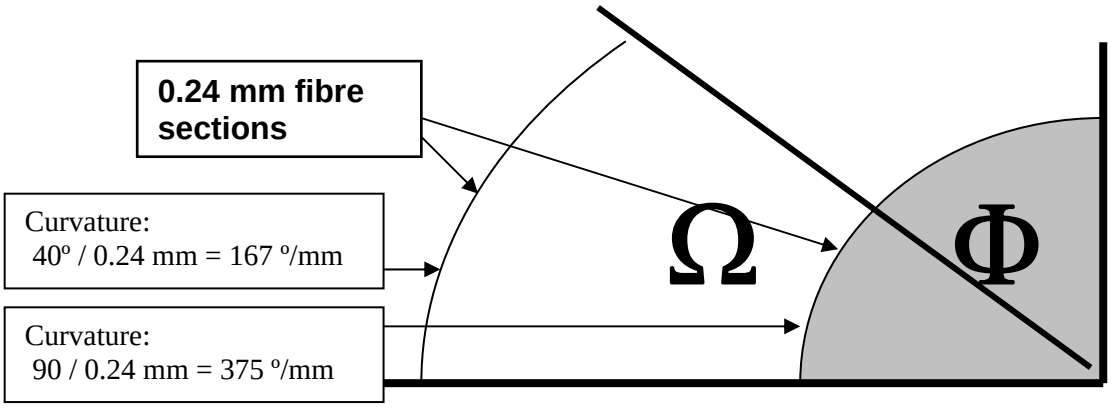
Opacity refers to a fibre's ability to block the transmission of light, and is the opposite of translucency. Medullated and nonmedullated fibres behave differently in this regard, and it is thus one way in which medullation can be indirectly measured. Measurements are taken of both mean opacity, and the standard deviation from the mean opacity (given in brackets).

Spin fineness refers to the fact that spinning performance of fibre can be improved either by lowering average fibre diameter or by lowering the variability in the diameter of individual fibres. At 25% coefficient of variation, fibre spins essentially as predicted by its MFD. But lowering the CV effectively makes the fibre process like one of a slightly lower micron, whilst raising CV tends to make it behave like a coarser fibre. This variation is expressed in the term "spin fineness", which is the way in which fibre of given micron and CV is expected to behave during spinning. The exact relationship is defined by a complex mathematical formula, but effectively, a 5% variation in CV, above or below 25%, is reflected in a 1µ increase or decrease in spinning fineness relative to MFD.

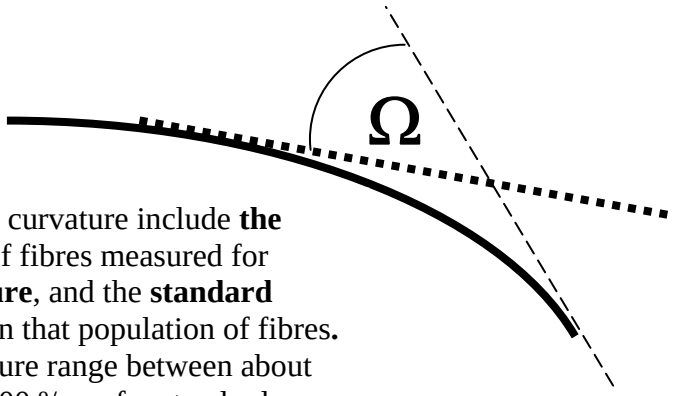


Fibre Curvature is a relatively new concept, which measures the rate of change in the direction of individual fibres relative to a straight line. It is measured over snippets of fibre just 0.24 mm in length, and expressed in terms of degrees/mm. It is suggested by some that it is the third most important fibre parameter after diameter and length, and it can be measured at any stage of the fibre processing chain (unlike crimp, which is lost after scouring and carding). Effectively, it is the number of degrees which an individual fibre turns in a specified distance. The curvature of a straight line is zero; a 5 cent piece has twice the curvature of a 20 cent piece. If one were driving a car at constant speed, curvature would be a reflection of how hard one had to turn the wheel.

So highly crimped wool of high frequency crimp will show high curvature, but low variation of curvature; broad and bold crimp will show low curvature, and low variation; flat and plain wools will show very low curvature and high variation.



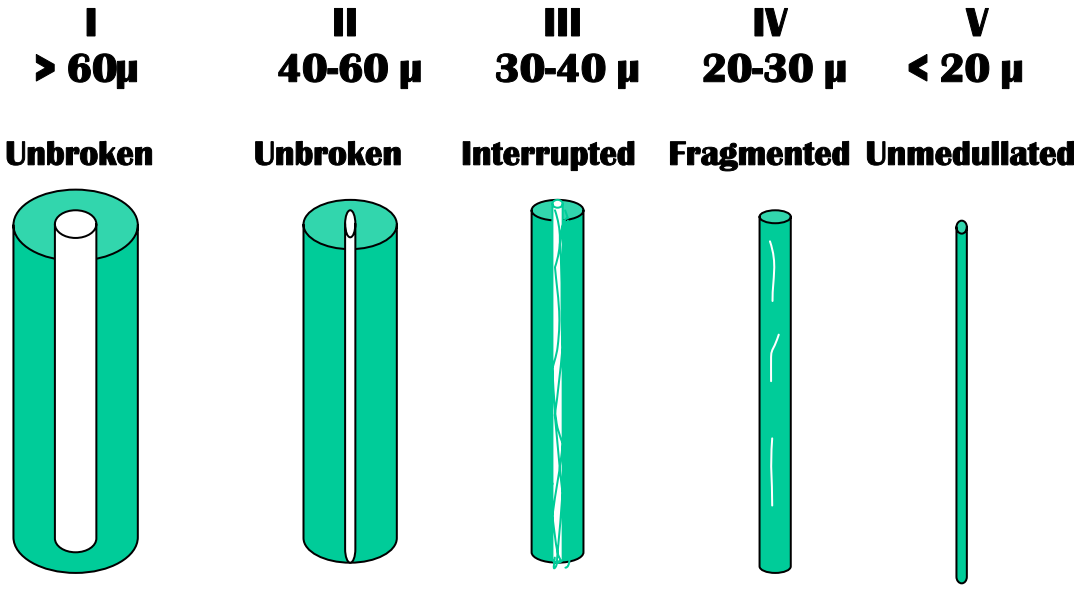
Fibre Curvature



The measurements relating to curvature include **the curve number** (the number of fibres measured for curvature), the **mean curvature**, and the **standard deviation of curvature** within that population of fibres**.** **"**Normal" readings for curvature range between about 60 and 130 º/mm, and 40 to 100 º/mm for standard deviation of curvature.

The last measurements on the fibre histogram refer to medullation. Fibres may be fully medullated, partially medullated or unmedullated, referring to the contents of the core of the individual fibres. The medulla, where present inside the cortex of the fibre, shrinks away as the fibre matures, giving rise to the description of a "hollow" fibre. Medullated fibres, because of their hollow or partially hollow centres, have different properties than solid fibres, and in general tend to be of higher diameter. The hollowness means that they take up dye less avidly and less predictably than unmedullated fibres, pose lower resistance to sonic and air flow streams used in some measurement systems, and transmit light differently than nonmedullated fibres.

VILLARROEL CLASSIFICATION



By measuring the amount of transmitted light from a beam passed through a fibre sample, and comparing that to the amount expected were there to be no medullated fibres, the number of medullated fibres can be calculated, as well as their fibre diameter, MFD, SD, and their proportion of the entire sample of fibres, calculated as a percentage, or a proportion by weight or volume.

When purchasing alpacas, remember you are purchasing an animal and its genetics, and not a histogram. Remember that the histogram quite simply tests the characteristics of a sample of submitted fibre. Its interpretation requires insight and knowledge. If it doesn't seem to match the animal to which it is attributed, don't blame the measurement: work out why. It is likely to be a matter of sampling or a false assumption What the histogram *fails* to record are some of the most important features in its interpretation: the date of the *sample* (as opposed to the date of the test); the age of the alpaca when sampled; the identity of the alpaca from which the sample was taken; the health of the animal at the time of sampling; the plane of nutrition experienced by the animal during the period of fleece growth represented by the sample; whether it was an active sire or lactating dam at the time of sampling and before; whether the sample was taken by guillotine or minicore; the length of the fibre sample; the site tested; and the sampling technique.

All these factors may have a significant influence on the interpretation of the data from the histogram.

The data is rarely wrong, and can be safely assumed to represent the correct data on the sample that was tested**. It is the assumptions made in interpreting those data that are invariably the source of misinformation.**

FURTHER READING:

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