



The physical properties of hides and skins are central to their behaviour within leather-making, the manufacture of an article, and the performance of that product in use. But these properties change according to location across the hide and the mechanical splitting of the skin structure.

An understanding of these variables requires investigation on a massive scale, nevertheless, based on chrome and vegetable tanned calf skins, studies have taken place and are recorded in detail.

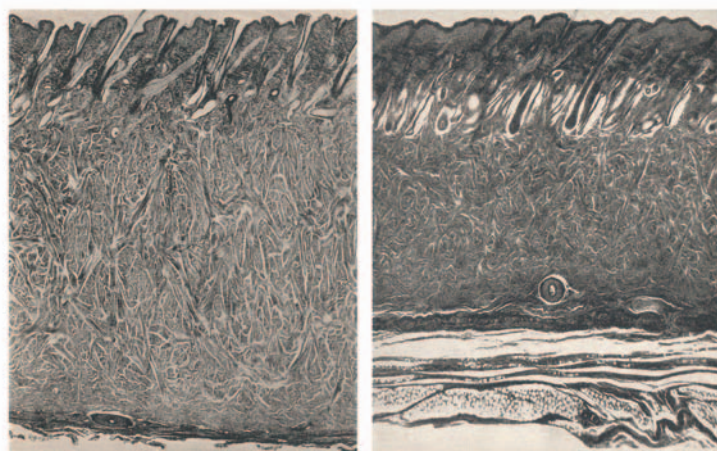
These values differ according to the hide or skin classification and manufacturing process, but the variations revealed are fundamental for all types of leathers.

This valuable work by the late John Arthur Wilson provides deep insight into the considerable differences that have to be taken into account in leather-making, within manufacture of the finished article, and the performance of that article in use.

Although this article was first published in 1941, it is still of major relevance today.

The properties of leather: strength and stretch across the skin area and the effect of splitting

John Arthur Wilson



Panel 1

The left and right images respectively show sections through a cow hide (mag. x16) and calf skin (mag. x30), and the difference in ratios between grain, corium and flesh layers are clear. Accordingly, differences in stretch and stretch can be expected, but the distribution of these properties across the area of calf skin - as determined by this investigation - is stated by the author as more or less common to all hides and skins.

Strength and stretch across the skin area

The tensile strength of leather and its resistance to stretching vary greatly over the entire area of the skin. These properties also vary according to the method and degree of tannage, the chemical composition, the degree of splitting, and the type and age of the animal.

To show the very important effect of location on the skin, it seems best to give complete results for calfskins. The entire area of four calf skins—two chrome tanned and two vegetable tanned—were cut into strips 1 by 6 inches (2.54 by 15.24 cm) with a die. In one skin of each tannage, the strips were cut parallel to the backbone, and in the other they were cut perpendicular to it.

Three measurements were made:

- The thickness of each strip before testing
- The tensile strength of the strip in kg/cm²
- The stretch, expressed as a percentage, under a load of 225 kg/cm²

Altogether 894 strips were tested^[Legend 1] from the four skins, and the maximum, minimum and average values are given in Panel 2.

In order to show graphically how strength and stretch vary as one moves from one part of the skin to another, the values for ➤



THE PROPERTIES OF LEATHER: STRENGTH AND STRETCH

Panel 2: Values for Tensile strength, stretch, and thickness of leathers tested

Parameters	Values	Chrome-tanned calf		Vegetable-tanned calf	
		Skin no.1	Skin no.2	Skin no.1	Skin no.2
Number of strips tested		206	197	251	240
Thickness mm	Maximum	1.62	1.53	1.50	1.32
	Minimum	0.92	0.82	0.74	0.84
	Average	1.17	1.12	1.06	1.18
Tensile strength kg/cm ²	Maximum	464	401	488	482
	Minimum	46	89	80	48
	Average	259	250	306	290
Stretch % under load of 225 kg/cm ²	Maximum	168	132	133	130
	Minimum	20	12	15	13
	Average	43	40	33	29

Kern have prepared two charts showing how the strength of chrome and vegetable tanned leathers varies as the grain or flesh layer is reduced in thickness by splitting.

THE TEST METHOD

A number of representative skins of finished chrome and vegetable tanned calf were selected.

On either side of the backbone of each skin, and with length parallel to it, an area of 6 by 25 inches (15.24 by 63.5 cm) was cut so that the inner edge was about 10 cm from the backbone, and the ends equal distances from the head and tail ends of the skin.

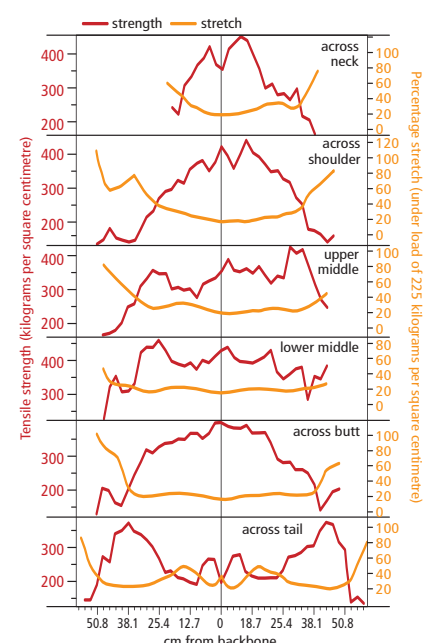
This area was the cross cut into twenty-five strips each 1 by 6 inches, and numbered consecutively. The odd strips were tested for tensile strength and resistance to stretch^[Legend 2]. The results were used to calculate the strengths of the even numbered strips, which were assumed to be the average of the strengths of the adjoining strips.

Each even numbered strip was split on a band knife machine into two layers

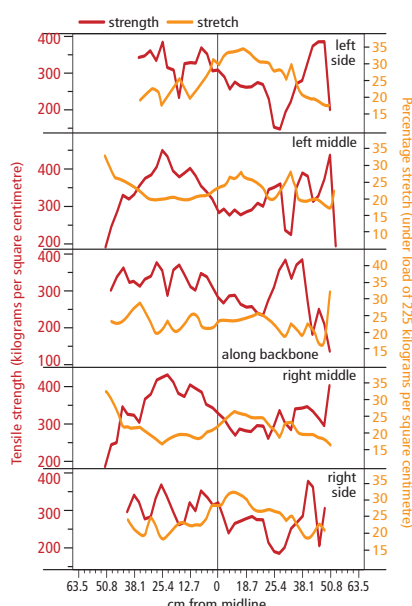
- In sample two the splitting was done so that the grain layer was 10%, and the flesh layer 90% of the total thickness.
- In sample four the splitting was done so that the grain layer was 20%, and the flesh layer 80% of the total thickness.

and so on. The strength of each split was then measured and compared with the calculated

**Panel 3: Variations in strength and stretch of a calf skin over the entire area
PULL EXERTED IN DIRECTION
PARALLEL TO LINE OF BACKBONE**



**Panel 4: Variations in strength and stretch of a calf skin over the entire area
PULL EXERTED IN DIRECTION
PERPENDICULAR TO LINE OF
BACKBONE**



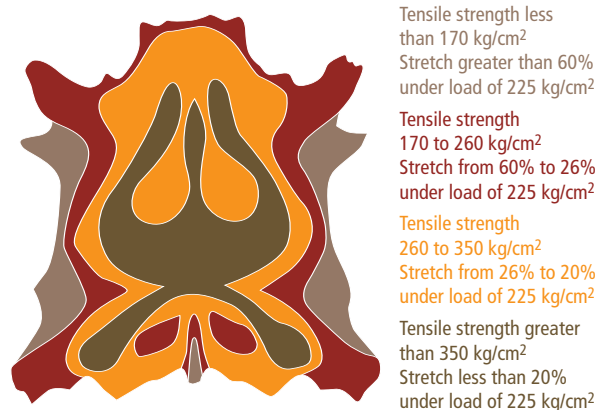
the vegetable tanned calfskins are plotted in the parallel and perpendicular directions, and are given as *Panels 3* and *4*.

All of these values, plus thousands of other values available to the writer, were used to represent the distribution of strength, stretch and solidity of structure that is more or less common to all hides and skins. This is given as *Panel 5*.

The effect of splitting

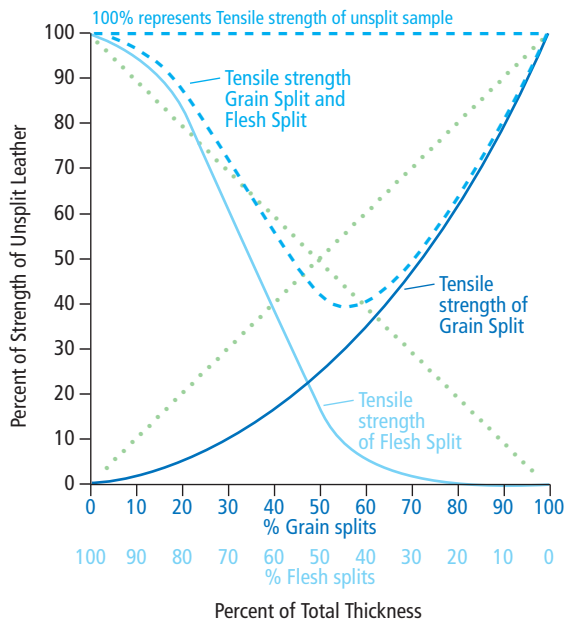
The tensile strength of leather is not uniform throughout its thickness. The uppermost layer is relatively weak, nearly all of the strength of the leather being in the reticulin layer. Any reduction in thickness of leather by splitting thus tends to alter its tensile strength and may either increase or decrease it per unit of cross section, depending on the strength of the part removed. It is thus apparent that the extent to which leather has been split or shaved in the process of manufacture will affect the result of any tests in which tensile strength is the dependent variable. Wilson and

Panel 5: Chart showing variations in strength and stretch of typical calf skins over the entire area





Panel 6: The relative strengths of splits of chrome-tanned calf leather compared with the strength of unsplit leather



Average tensile strength and thickness of unsplit leather
260 kg/cm² and 1.04mm

strength of the unsplit strip. For each kind of leather the investigation was repeated several times to ensure reliable results, and the findings for both types of leathers is given in *Panels 6 and 7*.

THE FINDINGS FROM THE INVESTIGATION

The curves represent strength per unit width and not cross section. The strength of the unit cross section can be obtained from the tensile strength and thickness details given in the Panels.

The relation of the curves to the cross lines indicates the variation. Where the curve is above the cross line, the strength of the unit cross section has been increased by splitting, and where below it has been decreased.

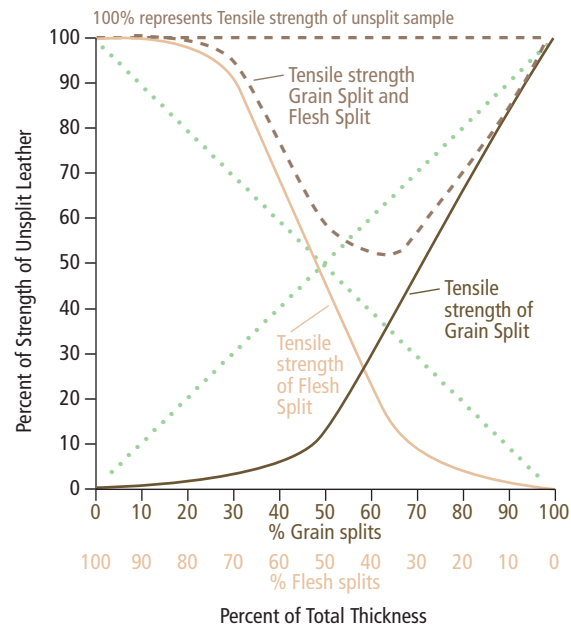
Splitting always causes a loss in strength per unit width, and the sum of the strength of the two splits is always less than the strength of the unsplit strip. When the uppermost curve in each Panel—being the sum of the strength of each pair of grain and flesh split—is compared from the line of 100%—being the calculated strength of the complete section—the loss of strength by splitting is revealed. The distance of the curve from the 100 line gives the total loss in strength due to splitting.

In this example, if the chrome leather shown in *Panel 6* is split into two layers of equal thickness, the grain layer will only be 26% and the flesh layer 16% as strong as the unsplit leather. This excessive loss in strength is the result of the severing of fibres in splitting, which is likewise responsible for the great loss in strength of the leather as a whole. It does not indicate a weakness of the reticulin layer compared to the grain layer.

The greater looseness of structure in the chrome leather is responsible for the greater maximum loss of strength, 60% for the chrome against only 48% for the vegetable tanned leather.

This is also shown in the greater weakness of the chrome flesh layers. In the chrome leather the flesh is weaker than the grain when it is less than 53% of the total thickness. In the vegetable

Panel 7: The relative strengths of splits of vegetable-tanned calf leather compared with the strength of unsplit leather



Average tensile strength and thickness of unsplit leather
324 kg/cm² and 0.91mm

tanned leather the flesh is only weaker when it is less than 41% of the total thickness.

The writer's experiments on heavy leathers indicate that the effect of splitting is similar in kind, but not in quantity to that described here. It must be remembered that the ratio of thickness of the grain to reticulin layer decreases with increasing thickness of the original skin (*reference Panel 1*).

The resistance to the leather to stretch was found to vary directly with the strength. Measurements were made of the load in kilogrammes required to stretch each strip to 1.25 times its initial length. Splitting caused a percentage in decrease in this value identical to the percentage decrease in strength. *Panels 6 and 7* can therefore be seen to indicate the resistance of leather to stretch.

Acknowledgement and additional information

This information has been drawn from "Modern Practice in Leather Manufacture" by John Arthur Wilson, published in 1941 by Reinhold Publishing Corporation, of New York, U.S.A. It is part of a chapter entitled "The properties of leather", and the information presented has been extracted from sections entitled "Strength and Stretch" and "Effect of Splitting". Although this is an abbreviated version of the original section, care has been taken to minimise change within the original text. There has been a conversion of Imperial to Metric measurements, and colour added to the figures.

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Legend

1] Before cutting into strips each skin was kept in an atmosphere of 50% Relative Humidity and the strip tested at once. The thickness was measured using the sensitive Randall & Stickney gauge, and the tensile strength was made using a Scott vertical machine.

2] All leather tested was in equilibrium with an atmosphere of 50% Relative Humidity.