

The scientific and commercial significance of variations in strength and stretch in leather

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It is well known that in any piece of leather there are significant differences in both the degree of stretch under a given load, and the tensile strength of the leather. These properties vary according to:

- type and age of the animal
- location of the sample (*see Panel 1*)
- methods of chemical processing
- reconfiguration of the fibre structure in the drying processes

Panel 1: Cross-section of hide in butt and belly parts



The dense fibre structure is clearly visible in this leather sampled from the butt area. The circular sections are fibres that have been severed as a result of sampling.



This shows the typically more open structure found within the belly areas. The white areas are open voids between the fibres, and this structure allows a greater degree of stretch under a given load when compared to samples taken from the butt.

John Arthur Wilson recorded these variations, where the tensile strength of samples and their elongation under a given load as kg/cm² were measured across the area of calfskins. The samples used in these investigations were cut both parallel and perpendicular (at right angles) to the line of the backbone, and the remarkable differences in performance according to sample location and the direction of sampling are shown in *Panel 2*.

The average of these parallel and perpendicular samples reveals the variations in strength and stretch across the entire area of these leathers, and are illustrated in *Panel 3*.

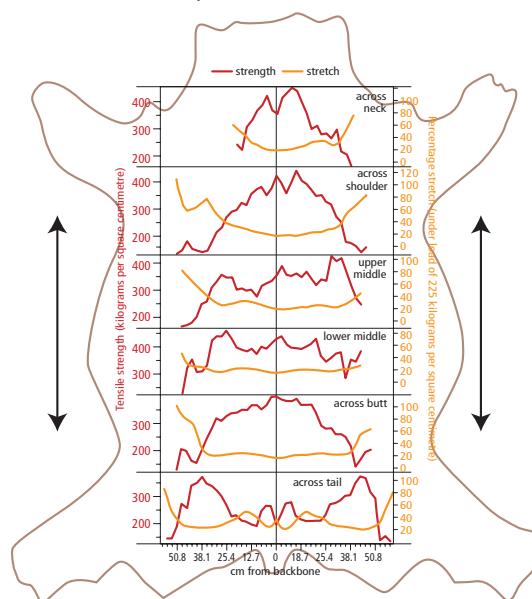
On the basis of experience, Wilson believed that these variations are more or less common to all hides and skins.

These findings are important to the tanner, as they provide a detailed insight into cross-hide variations in the major physical properties that are common to leathers in all stages of manufacture. However, to substantiate these understandings, more information can be gained by looking at the way that leather is managed when it is to be cut and assembled as a manufactured item for consumer use.

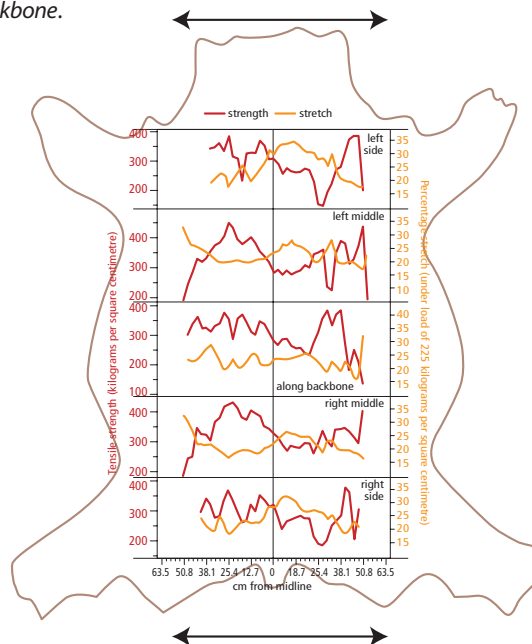
Clearly, any variations in physical properties—especially the

Panel 2: Cross-skin performance: variations in strength and stretch

Variations in strength and stretch of a calf skin over the entire area. Pull exerted in direction parallel to line of backbone.



Variations in strength and stretch of a calf skin over the entire area. Pull exerted in direction perpendicular (at right angles) to line of backbone.



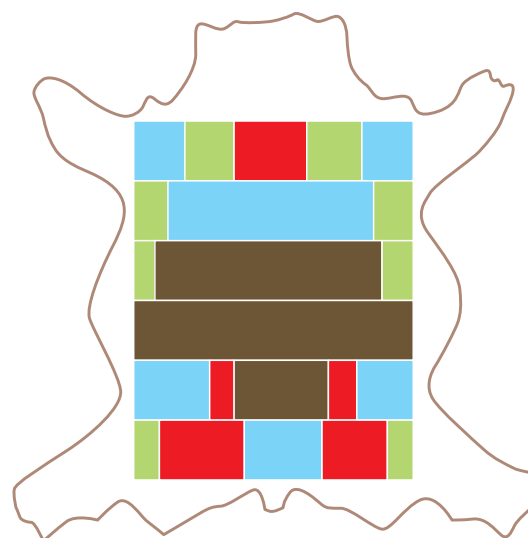


Panel 3: Typical variation in strength and stretch across a calf skin



Location	Tensile kg/cm ²	% Stretch: load 225 kg/cm ²
Butt	+350	-20
adjacent Butt	260 - 350	26 - 20
adjacent Belly	170 - 260	60 - 26
Belly	170	+60

Panel 4: Cross-hide variations as recognised by practical cutting experience



Tensile strength			
High		Moderate	
Good		Poor	

degree of stretch under load and the tensile strength—need to be accommodated within a manufactured item to both extract the best value from the leather and, in the longer term, to ensure customer satisfaction. This applies to almost all items manufactured from leather—garments, leather goods, furniture, automotive components, and footwear—as there is a need for shape retention during wear and use.

Irrespective of the end use, the most comprehensive insight into cross-hide variations can be gained from studying traditional footwear manufacture. This is because the relatively small cutting patterns can be positioned very precisely to gain maximum technical value from the different hide parts. The outcome from these placings becomes clear as the high stresses required in the construction of the footwear are applied and the retention of appearance and shape as a result of wear.

Variations in average tensile strength across a hide

The following observations have been extracted from “Boot and Shoe, design and manufacture,” by Edward J.C. Swaysland:

- the relative tearing strain is strongest across the ribs
- the strength is not even over any very large area
- the two sides of the butt are not as strong as the centre
- there is a relatively weak portion just above the kidneys
- although the centre of the neck appears to be strong, the skin is weak at each side

Based on practical observations and experience, Swaysland identified these areas of high, good, moderate, and poor values for tensile strength, and these are indicated in *Panel 4*.

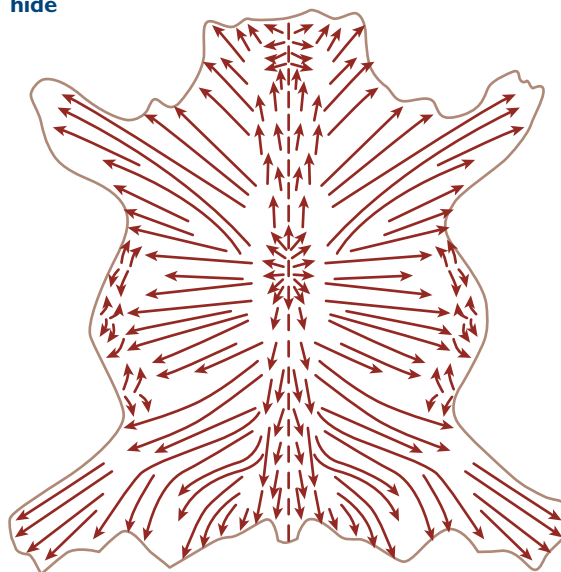
It is interesting to compare the values given in the rectangular areas in *Panel 4* with the corresponding areas in *Panel 3*. The precise measurements made on calfskins by Wilson, pre-1941, and the practical observations made by Swaysland, pre-1903, on

quite different materials show a remarkable similarity in cross-hide variations in terms of relative tensile strength.

The maximum and minimum values for strength and stretch across a hide

Panels 3 and 4 provide a good indication of variations in cross-hide properties, but are somewhat limited. The observations ►

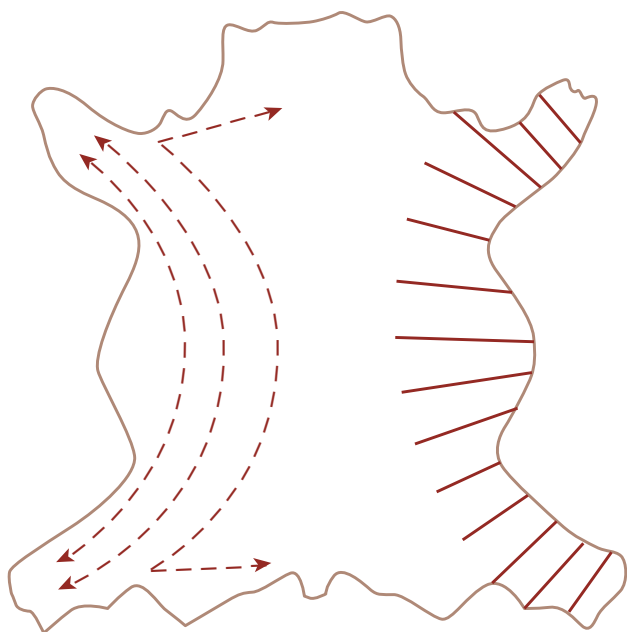
Panel 5: Typical direction of the hair follicle across a hide



The direction of the hair follicle approximately follows the underlying fibre direction. The lines of maximum stretch under a given load closely follow these lines.



Panel 6: The lines of the greatest resistance to stretch and maximum stretch across a hide



- Left side: lines indicate the 'lines of maximum tightness' (ie. the greatest resistance to stretch) across a hide.
- Right side: lines indicate the directions of maximum stretch across a hide.

made by Swaysland were supported by Wilson's work in terms of quantification for cross-hide strength (plus stretch under given load). However, these precise measurements limited the sampling directions to parallel and perpendicular to the backbone. The variations in strength between these two sampling directions are considerable, but they do not necessarily represent the maximum and minimum values.

The directions of maximum and minimum stretch in the area now recognised as the 'Official Sampling Position' (OSP) run respectively parallel and perpendicular to the backbone. However, across the rest of the hide the direction of minimum and maximum values varies. The maximum values run more or less in the direction of the hair follicle, as this roughly follows the direction of the underlying fibre structures. This is indicated in *Panel 5* (Legend 1).

This shows that, whereas the direction of maximum stretch in the OSP can be taken as parallel to the backbone, towards the belly area this has changed direction by approximately 90°.

The lines of maximum and minimum stretch

Variations in the directions of maximum and minimum stretch were recognised in craft footwear manufacture, and were put to good use. Over and above the quality of the leather across the hide or side—which the clickers (pattern cutters) continuously took into account—it was critical that the cut components functioned well in both

construction and wear.

J.H.Thornton states these central issues in "Textbook of Footwear Manufacture" as follows:

"A skin that could not stretch would make movement impossible for an animal. From this necessity for some stretch it follows that we should expect to find the greatest amount of stretch in leather where the movement of the animal was greatest. Obviously, this was near to the legs, in the belly and across the neck. Tests on good quality leather will show that all parts of the skin stretch, but in some places the amount of extension is considerable and permanent, and in others slight and temporary".

The lines on the left side of *Panel 6* show the direction in which the leather provides the greatest resistance to stretch. These are known in footwear manufacture as 'the lines of maximum tightness' (*not to be confused with the tightness of the break of leathers as known by the tanner*).

The lines of maximum stretch shown on the right side are intended to show where the greatest amount of stretch occurs. There is less stretch in the butt than any other part, and it is more uniform, but it is along the lines shown that the greatest amount of stretch is found, particularly in the shanks. These differences are significant and common to the great majority of leathers.

The art of cutting leather

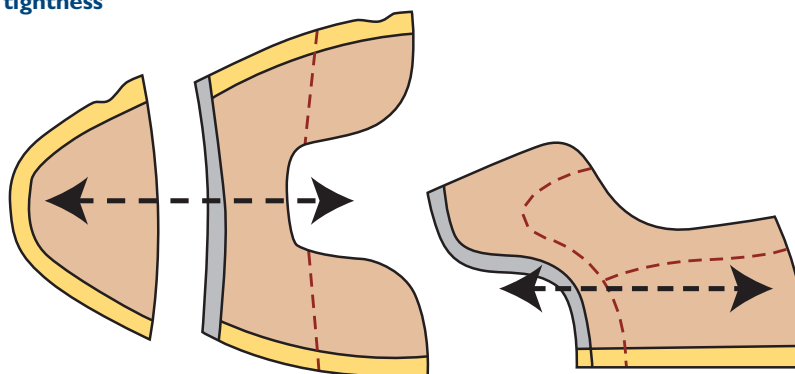
The variations found across each skin mean that the clicker had to exercise considerable care in placing his cutting patterns. Before he could do this he had to know not only what those variations were, but also what could be expected from the different parts of the shoe upper.

Over and above the need to cut the most visually important components from the best parts of the hide, it is vital that all major sections must be cut so that the lines of tightness (ie. the greatest resistance to stretch) run in the heel to toe direction.

This means that when the shoe components are assembled and stitched together, and in lasting and in wear, all of the components have the ability to resist stretch in the toe-to-heel direction. During the lasting operations, the predominant direction of stretch—which can be considerable—is perpendicular to this direction.

If the components are not cut in this manner, there is the danger of distortion of the shoe in both manufacture and in ►

Panel 7: Footwear components positioned in the direction of the 'lines of tightness'



The 'lines of tightness' need to run in the toe-to-heel direction of these major components for an Oxford shoe. The lines of maximum stretch run perpendicular to this direction.



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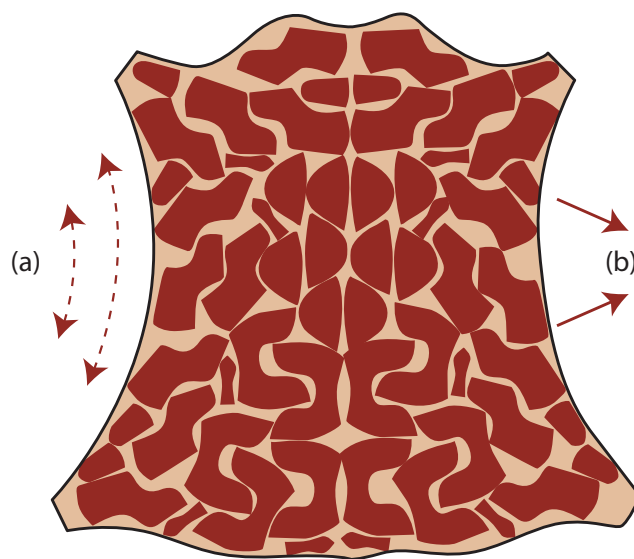
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STRENGTH AND STRETCH IN LEATHER

Panels 8: Cutting arrangement for the Oxford shoe



(a) indicates line of maximum tightness (greatest resistance to stretch)

(b) indicates line of maximum stretch

With reference to Panels 6 and 7, the positioning of the various patterns ensures the minimum stretch in the toe-to-heel direction of each component.

wear. As an example, the major components for a classic Oxford shoe are shown in *Panel 7*, where the directions of the lines of tightness—that is minimum stretch—are indicated.

In practice, this means that not only should the clicking knives for each component be placed to take into account the quality of the leather, but also the maximum and minimum lines of stretch. In the case of the Oxford shoe the various shoe components are cut from different hide parts, and each cutting knife should be placed at different angles to make best use of cross-hide variations.

This is illustrated in *Panel 8* where the Oxford components have been placed on a hide to take advantage of the natural lines of tightness and stretch. An example of a cutting arrangement for a quarter lining layout that similarly makes best use of these structural variations is shown as *Panel 9*.

Limitations imposed upon the leather user by the tanner

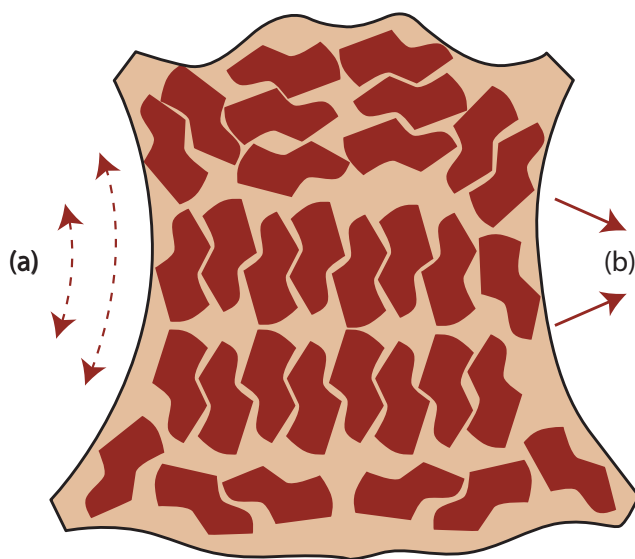
These observations were made when shoemaking was an art, and long before advances in pattern cutting efficiency were brought about by CAD/CAM systems.

These variations still exist, and play their part wherever leather is used. In soft leather garment manufacture, an understanding is needed of these directional variations otherwise the garment will become misshapen in wear. In automotive manufacture, where leathers are made to engineering standards, the need to stretch to within precise limits is paramount. In these situations, the natural stretch is limited both by the nature of the tannage, and the high degree of stretch applied and retained during drying operations. The manufacture of steering wheel leathers is very critical, as only sufficient stretch is needed for assembly, and virtually no stretch in use.

STRENGTH AND STRETCH IN LEATHER



Panel 9: Cutting arrangement for quarter linings



(a) indicates line of maximum tightness (greatest resistance to stretch)

(b) indicates line of maximum stretch

With reference to Panel 6, the positioning of these quarters ensures that there is the minimum stretch possible in the toe-to-heel direction.

The combination of practical craftsmanship and controlled investigations has provided a good insight into cross-hide variations for both tensile strength and percentage stretch. In particular, these measurements, as carried out by Wilson, are never likely to be repeated due to the huge scale of the investigations. Similarly, changes in footwear and other forms of leather-related manufacture mean that there is less awareness of the detail of behavioural difference across a hide.

These properties are fundamental and will always exist at different levels across the whole spectrum of leather manufacture. They are a factor for manipulation by the tanner, and accommodated—or used for advantage or disadvantage—in leather product manufacture.

Legend

1) The maximum values for stretch will not precisely follow the direction of the hair follicle. This is due to distortions of the hide during the life of the animal, and major structural deformations created by the tanner. This is mainly during first-time drying. For further information see: *Back to Basics: A Framework for Leather Manufacture, Essays 17 Parts 1, 2, 3 and 4, World Leather December 2006/January 2007, February/March 2007, April 2007 and May 2007 respectively.*

Acknowledgements

- "Modern practice in leather manufacture" by John Arthur Wilson.
- "Boot and Shoe, design and manufacture" by Edward J.C. Swaysland.
- "Boot and shoe production" by J. Korn.
- "Textbook of footwear manufacture" by J.H. Thornton.
- Leather and skin sections courtesy of Amanda Michel, Leather Wise Ltd.
- Technical discussions courtesy of Philip Lattaway, editor World Footwear.



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