(Version: 2024)

Leather:

AN OVERVIEW OF MANUFACTURE

Content and Structure

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Recommended by:

INTERNATIONAL UNION OF LEATHER TECHNOLOGISTS AND CHEMISTS SOCIETIES

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- “Overview” is for people who wish to become leather technicians.
- It contains information for those who need more than the most basic understanding of commercial leather manufacture as well.
- It follows the processes and operations used, and their purposes, for making leather from bovine hides, sheep and goat skins.
- It is designed for self-training, a foundation for distance learning, or expansion within formal education.

R.P.D.

This study is the second of three volumes:

Volume 1: Leather: AN INTRODUCTION.
This provides information for people new to the sector.
A review is recommended before beginning study of "OVERVIEW"

Volume 2: Leather: AN OVERVIEW OF MANUFACTURE
Information directly from manufacture for aspiring Leather Technicians.

Volume 3: Leather: THE TECHNOLOGY OF MANUFACTURE.
This is an advanced study, to provide insight and control within complex manufacture. It's content for the Technologist.
(More detailed information on "TECHNOLOGY" is set down in the Annex)

R.P.D.

- The Information presented in this volume is in condensed form, using a mix of headings, images from within the industrial environment, captions and text.
- It comprises this prologue, 8-Parts concerning manufacture, and an Annex
- It is designed for study via smart phone, and for larger display.
- It is intended for use and dissemination free of charge.

R.P.D.

- This is not an academic or chemistry-orientated work: content of that type is available elsewhere.
- The objective is to provide a clear overview of technical manufacture.
- It’s about making leather.

R.P.D.

Acknowledgements:

- Paul Evans: Leather technologist, leather manufacturer, finishing expert and lecturer in leather technology. We worked together within consultancy and education. In particular, thanks Paul for keeping me on track as this study was being brought together.
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- David Buirski: Editorial Consultant. Refinement and sharpening of technical writings and presentations. Much appreciated David.
- Richard Daniels: Leather manufacture, environment and technology transfer. Layout and design, schematics, images and panels unless credited otherwise. Images from around 80 industrial locations, mainly in Africa, Americas, Asia, China, and Europe.

R.P.D.

Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

Over and above the content and structure of this study, this section includes an expansion of raw material details given in "Leather: AN INTRODUCTION."

R.P.D.

RAW MATERIALS

This is an expansion of the basic details given in "Introduction" concerning the different raw materials used in leather making.

Bovine hides*, and skins from sheep and goat are used for the manufacture of leather.

Leather is a major resource based on this natural raw material.

It is used for a vast range of purposes.

Leather offers impressive physical performance combined with classic aesthetic characteristics.

* *Buffalo hide processing is an important part of leather making. Details for preservation and leather manufacture are essentially the same as processing cattle hides. However, the grain structure is distinctive, setting some restrictions on end use. Similar restrictions also apply to pigskin, being significant in volume too.*

<u>Cattle, sheep and goat are reared globally</u>

Argentina: cattle from ranching.

Zimbabwe: sheep and goat flocks.

- Cattle, sheep and goat are valued for their meat, milk, dairy products, wool and the nutrition they provide.
- They are never bred or husbanded for the value of the hides and skins.
- Ultimately, skins are a putrescible waste from the meat industry.
- When there is no demand, skins are dumped or sent for landfill.

<u>**Hide and skin uses**</u>

Dog chew products ?

Bio-gas generation with other wastes ?

- **Few alternative uses apart from gelatine manufacture, sausage casings, texturing in food production, and waste disposal.**
- **Other options can include bio-gas production, fertiliser or fish / animal feed supplements.**
- **These options destroy the world's only natural raw material that offers a strong and usable interwoven fibre structure.**
- **Can be converted into a viable product with significant end uses.**

Global meat production

The global herds and flocks total around 1 billion cattle, sheep and goat respectively.

Each year approximately 300 million cattle, 540 million sheep, and 440 million goat are slaughtered for food.

Residual from this meat production are:

- 300 million bovine hides at 25 Kg weight average.
- 540 million sheep skins at 1.5 Kg weight average.
- 440 million goat skins at 1.5 Kg weight average.

(Based on global meat production 2008 – 2017: Food & Agricultural Organisation of the United Nations)

Between 7 and 8 million tons of problematic waste

- Sufficient waste to create three pyramids the size of the Great Pyramid of Giza !
- Enough to cover an area of 7 to 8 sq km to a depth of 100 cm.
- Or a sustainable resource offering significant value in many applications.

(Image: credit unknown)

Hides and skins in leather manufacture

Hides:

Refers to skins obtained from mature cattle. These are heavy and have a large area and thickness.

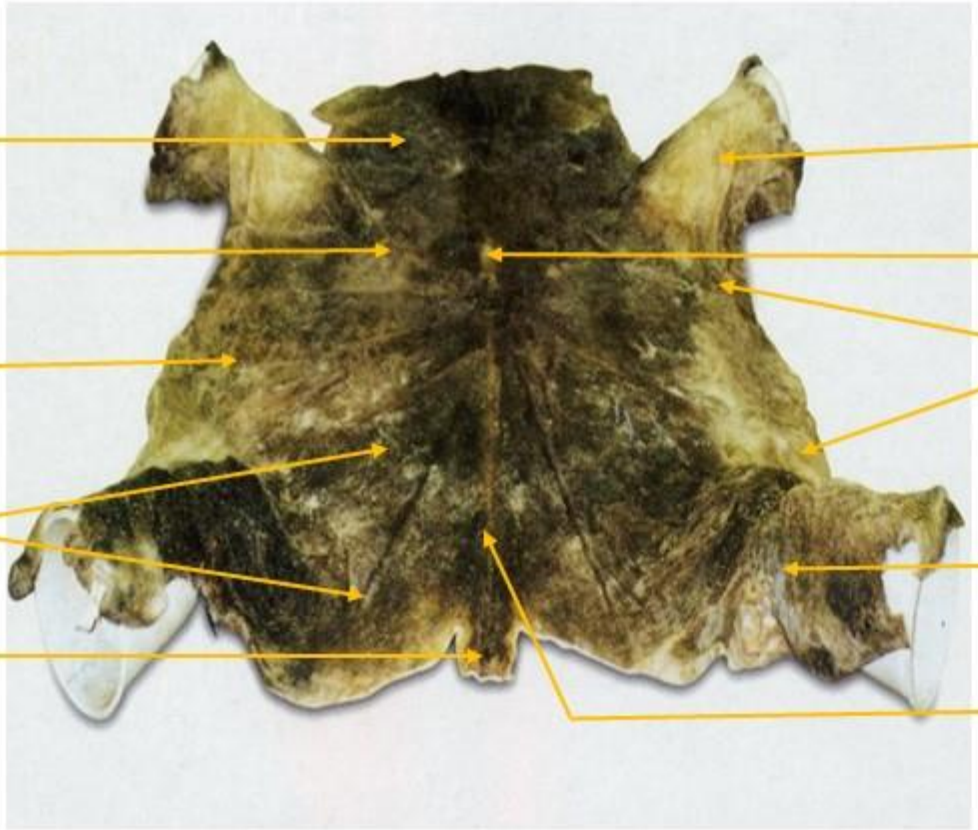
Leathers made from hides are mainly used for footwear, automotive purposes and furniture, larger size leather goods, clothing and industrial applications.

Skins:

Refers to skins from smaller animals such as goat and sheep. These are relatively light in weight, and have a small area and thickness.

Leathers from skins tend to be used for clothing, footwear, bags, small leather goods, and gloves.

Hide and skin structure



The shanks on this 30 kg hide have been spread open to show the strong natural contouring in these parts.

.Hide and skin variations

- There are significant cross-hide difference in structure.
- The butt and neck areas are high in substance (thickness) with a dense fibre structure.
- The neck areas carry significant growth lines.
- The shoulder areas are of slightly lower substance, with a weaker structure.
- The belly areas are thinner, less dense in structure, more flexible, and carry fine wrinkles and lines.
- The axilla parts are thin and stretch easily.

These are the raw materials for the creation of flat and consistent leather to customer specification.

The collagen structure

The complex skin structure.

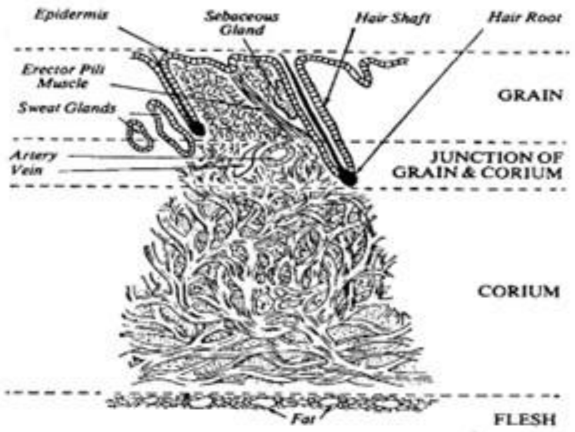
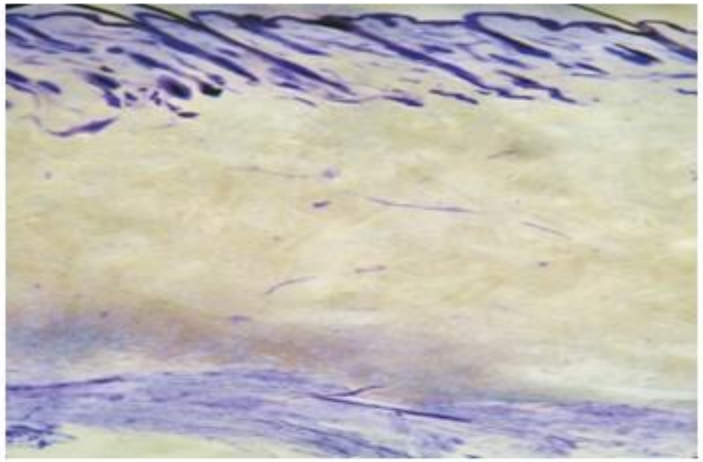


Image: grain and corium sections *(x20 mag).*



- A strong interwoven collagen structure is found within all hides and skins.
- In leather making, this is isolated as a base for the various leather types.
- It is central to all leather properties.
- Various other skin components need removal in the early stages of manufacture to release this complex matrix.
- The two parts of the structure that are of use in making leather are the grain and corium sections.

Diagram: Credit J.H.Sharphouse.

Image: Credit Amanda Michel.

-

The grain layer:

The grain has a hard outer layer known as the epidermis, with hair embedded in follicles reaching down into the skin structure. With the exception of sheepskins, where the wool may be of value, hair and the epidermis are chemically removed in the early stages of processing.

The basic structure of the grain is a densely interwoven fibrous tissue made from the protein collagen. This provides a fine, flexible and sensitive structure that is the key to good leather quality and the characteristic appearance of each leather type.

The corium:

The corium supports the grain layer and is relatively thick. The structure is fibrous, strongly interwoven but coarse. The density and interlacing of this collagen matrix varies according to the animal species and the different areas across the skin.

The angle of weave of these fibres strongly influences the flexibilty and stretch characteristics of the leather, and provides basic strength. These properties are modified during leather manufacture.

The junction:

The junction between the grain and corium is sensitive to both bacterial attack and mechanical stress. A weakening of this component can result in reduced grain support, leading to poor appearance on folding and flexing.

The flesh layer:

The raw skin carries flesh residues that are cut away in manufacture. Veins, fats and non-fibrous proteins are also contained within the matrix, and are mainly removed in processing.

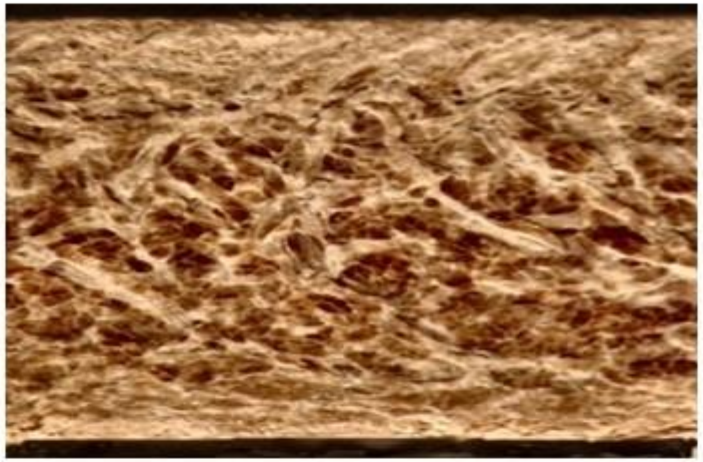
The diagram and image *(Page 9)* show these features, but the details are difficult to observe in raw skins.

However, once unwanted components are removed in early processing and leather making complete, the delicate structures of the grain and corium can be clearly observed.

Examples follow showing the structures and grain surfaces of leathers made from bovine hides, and goat and sheep skins:

Leather made from bovine hide

Cross-section of bovine leather *(x20 mag).*

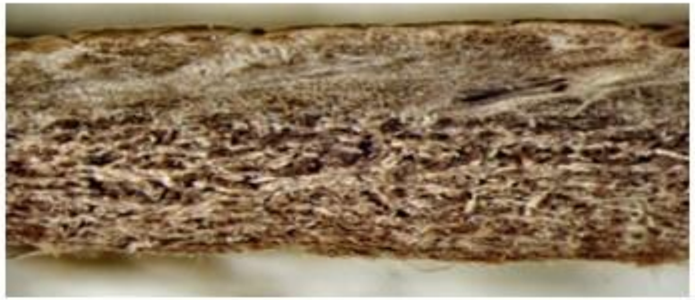


Grain surface of bovine leather *(x20 mag).*

- The section shows the isolated and tanned fibre matrix at the end of leather making.
- The dense top layer is the grain layer.
- The more open structure is the corium.
- This intricate structure is central to strength and comfort in use.

Leather made from goat skin

Cross-section of a goat skin *(x20 mag).*



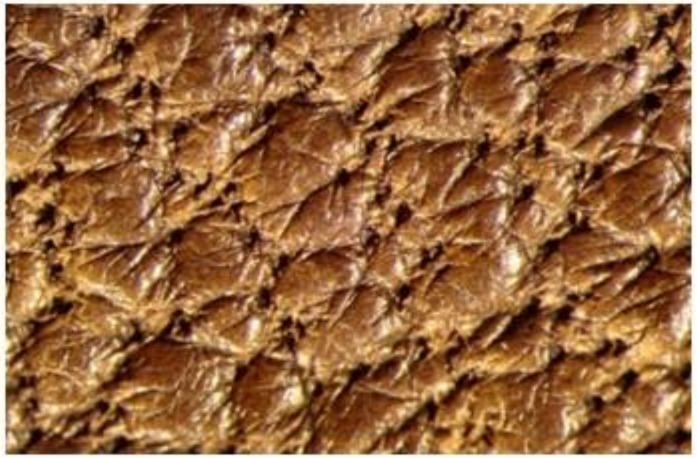
Grain surface of a goat skin *(x20 mag).*

- With goat skins, the grain layer is particularly tough and fine, and the corium more dense than a bovine structure.
- The grain surface is well defined and carries a characteristic pattern.
- This is a very tough product, ideally suited for the wear and tear required of small leather goods.

Leather made from domestic sheep skin

Cross-section of a domestic sheep skin *(x20 mag)*.

Grain surface of a domestic sheep skin *(x20 mag)*.



- Domestic sheep skins are similar in size to goat skins, but the structure is less compact.
- This is due in part to the high level of natural fat contained throughout the skin.
- After fat removal in leather making, this leaves voids throughout the structure.
- Also, the animal has been bred to provide wool, and the structure reflects this role.
- Can result in very soft leather but with lower tensile strength.
- The skin structure/hair of hair sheep is more similar to a goat than domestic sheep.

Hide and skin variations

There are many variations found within hides and skins prior to leather processing.

These differences are due to species, environment, welfare, age and post-mortem damage.

They affect the potential use of each hide and skin in leather making.

Zebu cross breed cattle in Brazil.

Dairy cattle Sweden.

- Variations and uniformity are dependent on the breed, geo-climatic conditions, husbandry, type of feed stuff, time of year, sex and age of the animal.
- Also, veterinary attention, health and general husbandry.
- All these factors influence the quality and texture of meat, but the quality and properties of the skin structure too.
- This influences the suitability of each hide in leather making, and the potential end-use.

Flock of hair sheep and goat, Eritrea.

Wool sheep, Iceland.

- This applies to sheep and goat skins too.
- Goat and hair sheep – bred for milk and meat - are very similar in appearance, and skin structure.
- Wool sheep – bred for the quality of wool and for meat – are clearly different to both goat and hair sheep.
- This is reflected in a higher grease content, and more sensitive, thicker, and open skin structure.

Every skin is unique, each with its own characteristics and structural differences.

And there are variations across each individual skin too. The butt area is relatively thick with a densely woven fibre structure, whereas the belly and shoulder areas are thinner, less dense and will stretch more readily.

With bovine hides and goats skins the natural fat contents are relatively low, say 2 – 4%, but with sheep the fat content can be more than 20%.

When this fat is removed weakened spaces are left within the structure.

The quality and uniformity of these materials can be reduced by many factors.

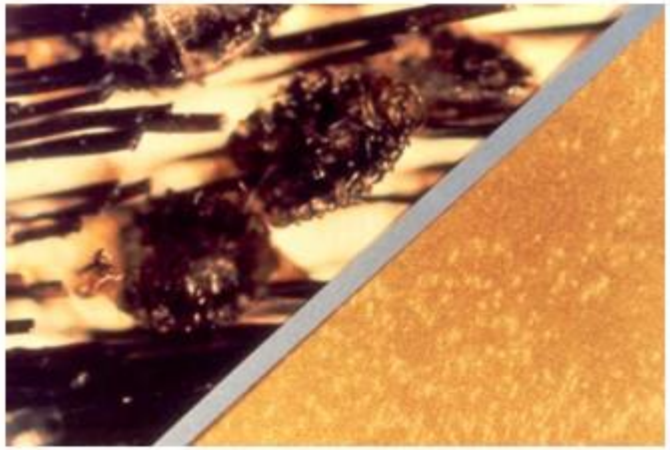
Damage from protective horns.

Scarring from branding.

- There is also life damage to take into account.
- This can be due to many causes - natural defence, thorns and general abrasions.
- But there can also be damage caused by their management - branding, prod marks, barbed wire, transit and lairage.

Grain damage by ringworm.

“White-spot” infestation/damage.



- And there is damage from disease and infestations.
- Veterinary services and good animal welfare can minimise these forms of damage.
- All influence the potential quality, cutting values and utilisation of the finished leather.

(Images: credit unknown)

Hide and skin preservation

As part of meat production, the carcass is hoisted by the hind legs and bled from a throat incision. This improves the colour of the meat, but it also removes a component from the skin that can readily putrefy.

Cuts, or markings, are carefully made in the skin to assist in flaying *(stripping)* the hide from the carcass, and to maintain a uniform hide/skin shape. The hide is then removed from the carcass by mechanical pulling or by hand.

Skin damage can result from excessive tension caused by pulling smaller carcasses, while hand flaying requires a considerable amount of lateral cutting in separating the skin from the meat and fat. Flay damage can include deep cuts, gouges and holes in the flesh side of the skin, affecting the potential thickness *(substance)* obtained from the final leather.

Hides and skins are susceptible to putrefaction after animal slaughter.

Over and above processing fresh hides, there are four main options available to prevent decay, and to preserve the integrity of this complex protein structure.

Preservation by wet salting

Application of salt on small scale.
(Usually a mechanical operation)

Hides can be stored for long periods.

- Ideally, hides are washed, chilled, and the surplus flesh removed by a fleshing machine.
- They are preserved by applying salt to the flesh side, then stacking in piles.
- The salt absorbs water from the skin, which drains away as a brine solution over many days, causing partial drying.
- A liberal application of salt ensures good water removal and inhibits bacterial activity, thus safeguarding the skin against further bacterial action
- Wet salted hides can be stored for long periods of time under cool and dry conditions.

Wet salted domestic sheep.

Storage times may be long.

- Similarly, small skins can be preserved by wet salting.
- The use of sheep and goat for human consumption often varies, according to times of fast and feasting.
- Accordingly, there are periodic shortages and oversupplies of small skins.
- For this reason, long storage times are common that regulate supply and manufacture.

Preservation by brining

Raceway for brine preservation.

Brined hides awaiting process.

- Strong salt solutions can be used for preservation.
- Brine curing is a fast technique suited to high volume throughput and is commonly used in the USA.
- Immersion in concentrated brine solution is required until penetration throughout the structure is achieved.
- Rotating paddle blades keep hides/skins and solution in motion.
- Removal from raceway is by movable conveyor.
- Once drained, goods can be lightly salted.

Preservation by air drying

Hides air dried under light tension.

Cutting away residual tissue on drying frames.

- If salt is not available hides and skins can be stretched on a frame and dried in the shade.
- This is particularly successful for smaller enterprises in hot climates.
- The taut vertical presentation during drying allows careful removal of any residual flesh.
- This improves drying and provides a very clean structure.
- Delays before preservation, or a slow drying rate, increase risks of bacterial damage, especially to the sensitive grain layer.
- Air drying ensures very long storage times.

Preservation by dry salting.

Air drying lightly salted skins.

Example of dry salted small skin.

- Dry salting is another method of preservation used in hot climates.
- As the first step in preservation hides and skins are lightly salted to stop putrefaction.
- They are then air dried, where the loss of water ensures long term protection.
- Wet salting produces the best result, but air drying and dry salting are very useful techniques.

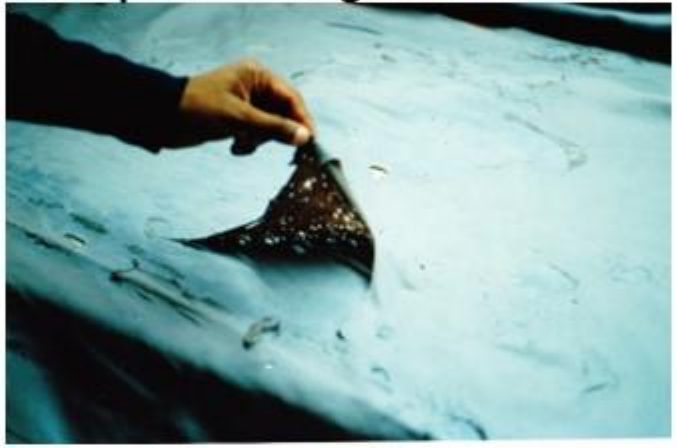
Processing fresh hides

Packaged and palletised fresh hides.

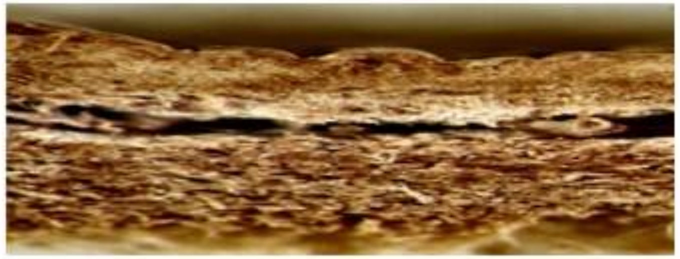
Line-conveyor receipt of fresh hides.

- Hides are increasingly processed without preservation.
- Fast reliable transport and close liaisons between abattoir and tanner are essential to avoid putrefaction.
- Ice chilling is often part of these systems.
- High level of organisation at the tannery required for receipt, assessment, gradings, and input.
- Avoids use of any preservation – saves materials, labour, and waste.

Putrefaction damage: extreme example showing delamination.



Breakdown of grain and corium junction with domestic sheep skin.



- Poor preservation can cause many problems in leather making.
- Often not obvious in the preserved state, this is exposed in process.
- It may lead to holes throughout the structure or delamination of the grain from the corium.
- There may be more subtle fringe effects that remain undetected until manufacture is complete.

Heavily finished leather with good grain characteristics.

Heavily finished leather with poor grain break.

- Low level putrefaction may result in a scuffed grain appearance that is not detected until leather is dyed or even finished.
- Damage within the main structure can lead to poor appearance on folding *(break)* or flexing.
- All a loss of potential and a down grade of quality for end use.

Review:

Hides and skins are putrescible waste from the meat industry.

There are limited uses for this material apart from leather manufacture.

Each skin has an intricate structure that can be converted into a wide range of leathers.

Continues as:

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 1)

The removal of unwanted materials and extension of the structure

Author: Richard P. Daniels

Recommended by:

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(Version: 2024)

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 1)

The removal of unwanted materials and extension of the structure

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Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

This section includes a summary of hides and skins as raw materials.

Part 1: The removal of unwanted materials and extension of the structure.
Part 2: The introduction of new materials and extension of the structure.
Part 3: The removal of water and reconfiguration to a flat form.
Part 4: Application of the finish.
Part 5: Different types of bovine leathers.
Part 6: Small skins: hair sheep and goat: grain leathers.
Part 7: Small skins: wool bearing sheep: double face, shearling and rugs.
Part 8: Discussion.

Annex.

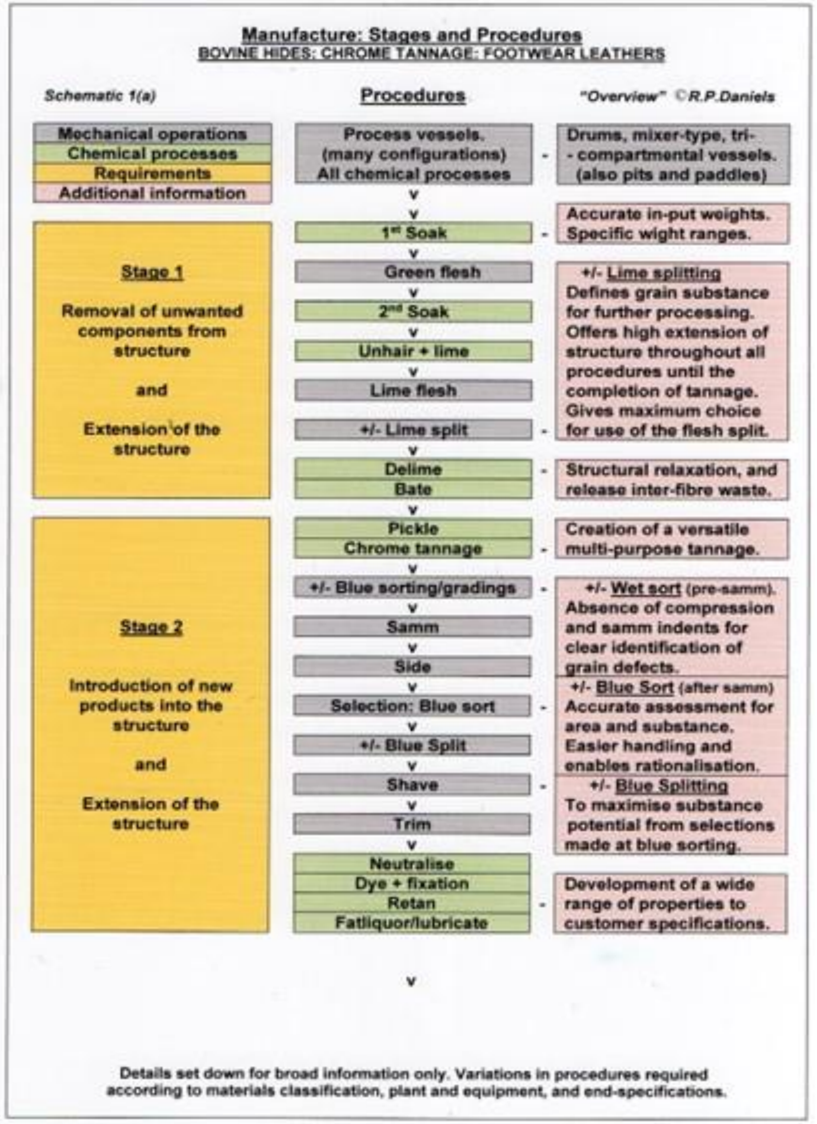
There are many different types of leathers produced from both hides and skins. As a starting point it is useful to follow the conversion of raw bovine hides into footwear leather using chromium compounds for tanning.

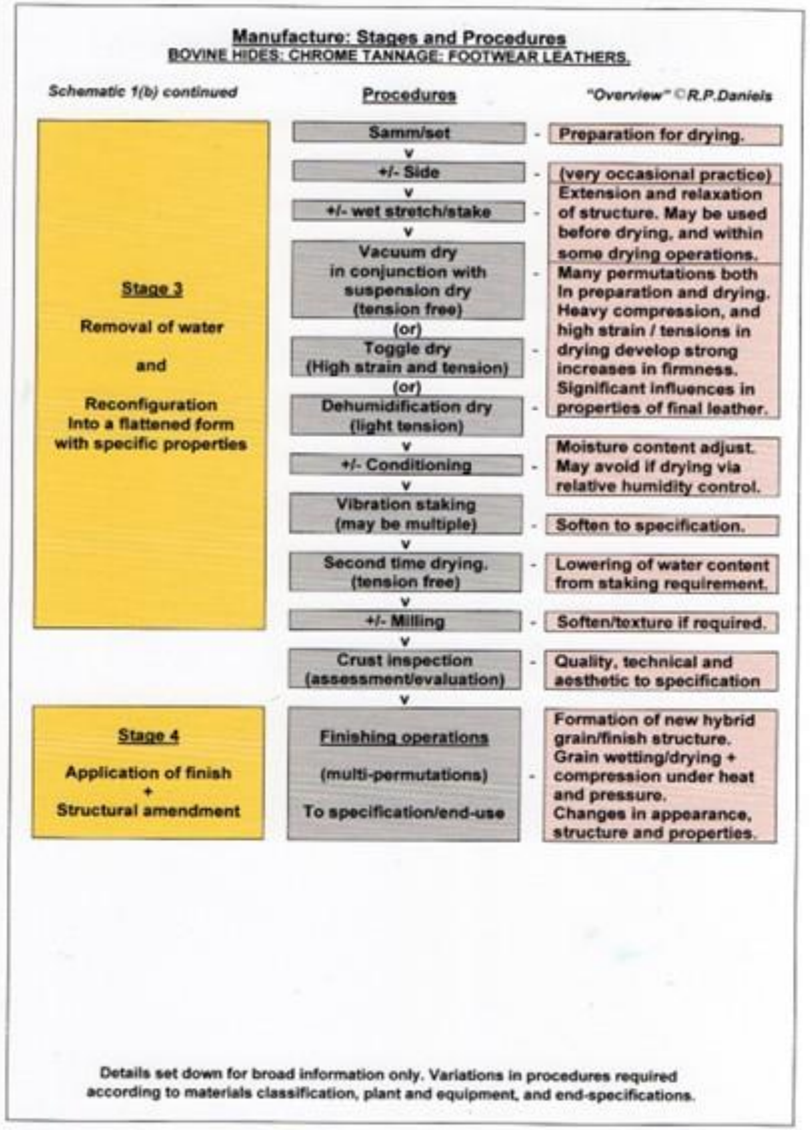
This is because:

- **Bovine hides are the main source of leathers produced.**
- **The majority of leathers are used in footwear construction.**
- **The use of chromium-based products has been established as the major tanning process for more than 100 years.**
- **The manufacture of other leather types can relate to this technology, and are detailed as appropriate.**

Procedures required for these footwear leathers are given as *Schematic 1a and 1b:*

Schematic 1: The conversion of hides into leather





These schematic identify four Stages within leather manufacture, and these are discussed in this and the following three Parts of Overview.

But first, it is useful to consider the processing vessels. These are central for the management of both the chemical processes and the significant forces applied to goods in process.

Drums are the most common type of vessel used for all operations.

The processing vessel and its operation

The basic processing drum.

Plant with full support systems.

- Traditionally, wooden drums are used for chemical processing.
- The role of these vessels is critical.
- On rotation, hides and chemicals in solution *(floats)* are mixed as part of the chemical process.
- Considerable forces are applied to the materials during these movements.
- These forces help determine the outcome from reactions as chemicals penetrate the hide structure.
- At the same time the structure is extended as part of shape change *(reconfiguration)* from a rounded to a flattened form.

Shelves fitted in stainless steel drum.
(Drain via perforated body section)

Pegs fitted in a wooden drum.
(Drain via perforated side channels)

- The forces applied are governed by the speed of rotation, the weight of the load, the volume of float, time, and internal construction.
- The most basic drum construction comprises 6 shelves set horizontally across the drum body.
- These apply a moderate drop action, but also cause a rolling motion to the goods that can cause tangling.
- Pegs provide a more gentle and continuous teasing action and help avoid tangling.
- Combinations of the two are common.

Deep shelf fittings: 4 shelves in this vessel.

One section of a stainless steel Y section vessel with elongated pegs.

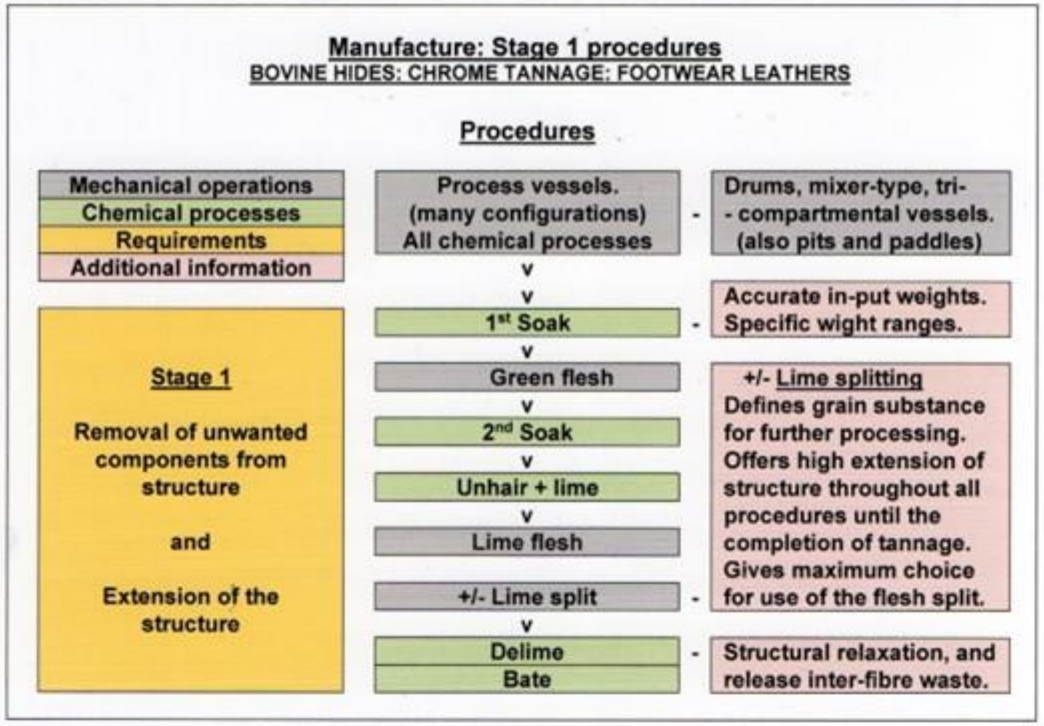
- Shelves at between 25 - 40% of the drum radius are also fitted.
- These apply a high lift and drop action.
- They provide good mechanical action and help avoid tangling.
- Known as deep shelf drums, they are fitted at 3 or 4 shelves per drum according to shelf length.
- Tri-compartmental (or Y section vessels) are also used for more delicate leathers.
- The drum is divided into 3 sections by perforated divisions.
- These normally have small pegs fitted to help avoid tangling.

Stainless steel hide processors.

Paddles: wood and polypropylene.

- Polypropylene and stainless steel are also used in constructions.
- And different types of vessels are employed, including specialised processors.
- Various internal arrangements of shelves and pegs are used in all vessels for the movement of goods and floats in process and the application of force.
- Paddle arrangements are used occasionally.

Stage 1 procedures



- Within Stage 1 procedures a strong and flexible collagen matrix is provided for the final leather.
- The procedures used are part of a gradual extension of the hides and skins from a natural rounded structure to a flattened form.
- This involves both chemical modification of the hides and skins, and the careful application of force throughout all processes and operations.

SOAKING PROCEDURES

The objective of soaking is to remove salt, dirt and contaminants from the skin and fully rehydrate the skin/protein structure. This is in preparation for the unhairing and liming process.

Soaking times can vary from a few hours for fresh hides to several days for some types of air-dried hides.

Bactericides are included to prevent decay of the skin, and wetting agents / detergents, mild alkalis, and selected enzymes can be used to accelerate the soak.

Preparation for soaking

Loading a desalting cage.

Desalting cage and enclosed conveyor for drum feed.

- The hides may be fresh or salted.
- Salted hides are often loaded into open cages and tumbled to remove loose surface salt and to open the hides.
- On exit from the cage they can be transported to specified drums using conveyor belts and delivery chute arrangements.

Hide movement by forklift truck.

Grab manipulator for drum loading.

- Various techniques are used for loading into the soaking vessels.
- Forklift trucks are used extensively, as well as grab manipulators too.

Hide delivery by line-conveyor.

Load cell for weighing each hide.

- Hides are weighed as they enter production to ensure accuracy in chemical use in subsequent processing.
- This may be before loading by forklift or grab, or on a line-conveyor using sensors set on the delivery lines.
- When using conveyors, hides can be directed automatically to drums according to the weight range and to a specified load weight.

1st soaking process

Hide discharge after dirt soak.

Hides for delivery to fleshing.

- The 1st soak removes some dirt and salt from the structure.
- It is not intended to fully rehydrate the hide.
- Flesh may be cut from the hides at this stage, with trucks or line conveyors used for transport to the operation.
- Known as "green fleshing" some hide flexibility is needed for good extension in this operation, but with sufficient firmness for good cutting.
- If there is little residual flesh this operation is often omitted and the soaking processing continues without unloading.

(Fleshing operations: Pages 25-31)

The 2nd soaking process

Hides reloaded if green fleshed.

Inspection of fully wetted hide.

- If the hides are green fleshed, they are reloaded for the 2nd soak *(main soak).*
- This fully cleans and rehydrates the structure in preparation for the unhairing and liming processes.
- The hides are inspected after the main soak to ensure that they are thoroughly wet back, especially the thick and densely structured parts.
- This is to ensure uniformity in the unhairing and liming processes.
- These processes can take place in the vessel used for soaking, but hides are often unloaded and transferred to another area.

Review:

There are two soaking stages:

1st Soak:

The objective is to remove dirt, salt and contaminants from the surface. This is not a complete soaking of the skin and leaves a firm structure.

There may be a fleshing operation after the 1st soak, but depending upon the amount of residual flesh this machine operation is often avoided.

2nd Soak:

Hides are fully hydrated in preparation for unhairing and liming, with some non-structured proteins dissolved and released from within the structure.

Once the hides are fully soaked the unhairing phase can commence.

UNHAIRING AND LIMING PROCEDURES

There are two types of unhairing and liming processes:

Hair dissolving processes:

Under alkaline conditions, the chemicals sodium sulfide and sodium hydrosulfide can break down the protein keratin - the main component of hair – leaving the collagen structure intact. It is therefore possible, under careful control, to safely remove hair from the skin without causing damage to the sensitive grain layer.

This hair removal is carried out as the first step of a combined unhairing/liming process where the hair breaks down into solution.

This often referred to as a hair-burn process.

Hair saving processes:

Hair can be removed from the hide largely intact instead of dissolving it.

The technique is similar to the hair dissolving system, but the hair shaft is first made chemically immune to breakdown by a small pre-addition of lime.

The hair root is then dissolved using mainly sodium hydrosulfide, the released hair being separated intact from the float using specialised filtration equipment.

Regardless of technique, after hair removal the hides enter the liming stage. Here, they are subjected to controlled alkali swelling to cause an opening or separation throughout the fibre structure. Mainly uses calcium hydroxide *(lime)* as the source of alkali, often with additional sodium sulfide. Controlled additions of water are used for management of the swelling.

Unhairing and liming

Fully soaked hides pre-unhairing.

Hides slightly swollen with hair loosened after 2 hrs processing.

The removal of hair:

- Water additions *(the float)* are carefully controlled for volume and temperature.
- The volume affects the chemical concentrations, and temperature the breakdown rate of hair and modifications of the collagen structure.
- Additions of mainly sodium hydrosulfide/sulfide are required to start breakdown of the hair.
- At the end of the hair loosening stage the hides are slightly alkaline-swollen.

Hair easily removed from the grain.

Hair filtered from the processing float.

- At this point in the process, the residual hair can be readily pushed from the hide.
- This leaves a clean grain surface.
- The process can continue with the hair being fully dissolved, or removed from solution and dewatered.
- In either event, the hides are in a suitable state for the liming stage.

The liming stage:

Swollen hides at the end of liming.

Removal of hides from the area.

- Addition(s) of lime +/- sodium sulfide and an increase in the float level by water addition is needed in the liming stage.
- This causes a gradual swelling throughout the hide structure.
- Unwanted proteins are dissolved in this alkaline process, and the collagen fibres in the structure separated.
- This ensures that the final leather can achieve the softness and flexibility required.
- On discharge from the liming vessel the hides can be removed from the area by line-conveyor or forklift.

Review:

Unhairing and liming is a two stage process where hair is first removed from the skin structure - either being dissolved or removed intact - followed by controlled alkali swelling.

The liming stage has a decisive effect on the character of the leather produced.

Lime is the main source of alkali in this process as it is only sparingly soluble in water and ensures a constant level of alkalinity.

Sodium sulfide can also be incorporated. When dissolved it may be viewed as providing both sodium hydrosulfide as the major unhairing aid, and sodium hydroxide or caustic soda. This makes the liming solution more alkaline and accelerates the process.

Other products - wetting agents, enzymes, sodium hydroxide, amines, urea and auxiliaries - can also be included in both the unhairing and liming steps.

Liming is carried out with three major objectives:

1. Alkali swelling of the skin to physically separate and open the collagen fibre structure.
2. To cause break down and solubilise non-structured proteins and complex sugars within the collagen structure that would harden the final leather unless removed before tanning.
3. To chemically modify the collagen for the reception of chemicals used in tanning.

There is also partial hydrolysis of natural greases within the structure, and this assists in their removal. Flesh residues become swollen, too, and this helps in their removal during the limed fleshing operation.

These processes are generally performed in drums and sometimes in hide processors. It is usually managed with handling over a 24 hour-cycle but this varies depending on the type of skin, and the type of leather to be produced.

FLESHING OPERATIONS

There are two different types of fleshing:

Green fleshing:

Removes flesh from the hide structure if relatively large quantities remain. This is performed after 1st soak *(or dirt soak)* and before the 2nd soak *(main soaking stage)*. This step is often omitted.

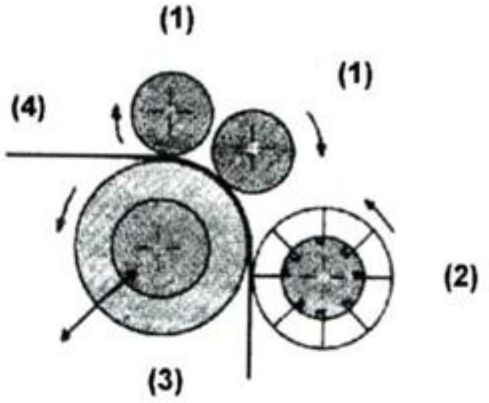
Limed fleshing:

Performed after liming and unhairing as an essential step in preparation for the lime splitting operation.

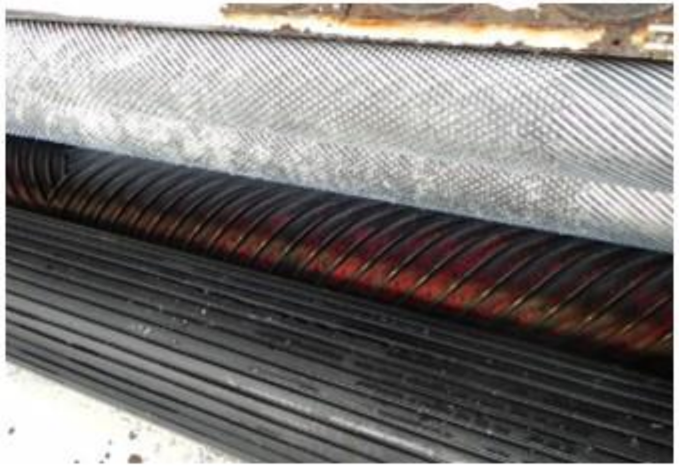
Two types of machines are available for these operations.

The basic fleshing machine *(out-feed action)*

Transport rollers and fleshing cylinder arrangements.



Knife cylinder and transport rollers.



1) Transport *(grip or feed)* rollers.
2) Knife cylinder: steel roller fitted with spiral knife blades *(helical arrangement)*.
3) Support roller: steel covered in rubber to accommodate differences in cross-hide thickness.
4) Hide: grain down – fleshing action on return feed.

The angle of the cutting blades ensures that the hide is well extended at the time of cutting/return feed.

This extension is part of the reconfiguration from a rounded shape towards a flat form.

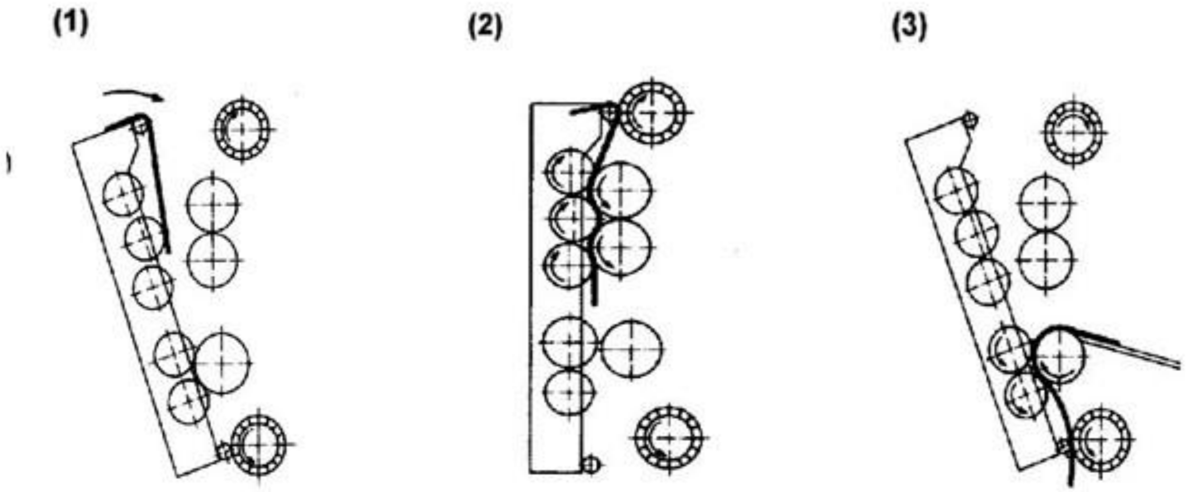
Placing hide on the support roller.

Flesh cleanly removed on return feed.

- Limed hides are alkali swollen and rubbery in texture, but the roller assembly is designed to suit these properties.
- This swelling enables clean flesh removal from the structure.
- This removal ensures uniform chemical penetration in subsequent processing.
- The pressure applied to the hide during this operation squeezes dirt and hair debris from the grain.
- It also consolidates the structure in preparation for the limed splitting operation.

The fleshing machine *(through-feed action)*

Fleshing in through-feed is an alternative machine configuration:



Presentation and out-feed:

1) Feed grain down as fleshing cycle commences.
2) Fleshing butt part.
3) Fleshing neck part on transport out of machine.

Presentation: through feed operation.

Conveyor out feed from green fleshing.

- Handling of the hide is simplified in the through feed configuration.
- The hide is presented to the machine flesh side up.
- The through feed rate is very fast.
- Out feed is flat and grain side up.
- This suits conveyor belt linkage directly to the limed splitting operation.
- In this example the machine is being used for green fleshing.

Review:

Green fleshing:

Can be used to cut surplus flesh from the hide after a dirt soak. This is to achieve a more uniform main soak and penetration of chemicals in the unhairing/liming processes. If the hides are relatively flesh-free, this operation is often omitted.

Limed fleshing:

Residual flesh and tissue is removed from the hide structure to ensure a clean skin for good presentation to the splitting operation. The operation squeezes dirt and debris from within the grain layer, and consolidates the structure.

The limed hides are slippery, firm, alkaline swollen, and semi-translucent. Any residual flesh and tissue can be cleanly cut from the flesh section. This is a very important operation, and it is unusual to rely on green fleshing alone.

Both types of fleshing are part of a general relaxation of the hide structure. They are particularly important for the removal of grease where the hide has a high natural fat content.

Handling procedures can be highly rationalised in this otherwise difficult operation.

LIMED SPLITTING OPERATION

Hides have considerable variations in thickness *(substance)* both across the hide structure and between individual hides.

By feeding the limed hide against a moving band knife, the swollen structure can be split horizontally into two layers, the top grain layer being uniform and to the required substance.

Preparation for limed splitting

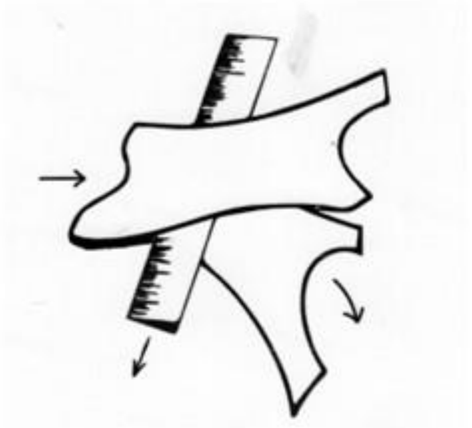
Protection: face shield for knife use, safety glasses for any splashes.

Hide delivery to splitting operation.

- After limed fleshing, the hides are well extended and clean.
- The hides can be stacked after fleshing, or moved from the area using a conveyor system.
- Trimming is required, with removal of any damaged peripheral parts for optimum presentation to the splitting operation.
- This operation is often performed on a horizontal belt conveyor placed behind the fleshing machine.
- This conveyor also enables direct presentation of the hides to the limed splitting operatives.

The lime splitting operation *(through feed action)*

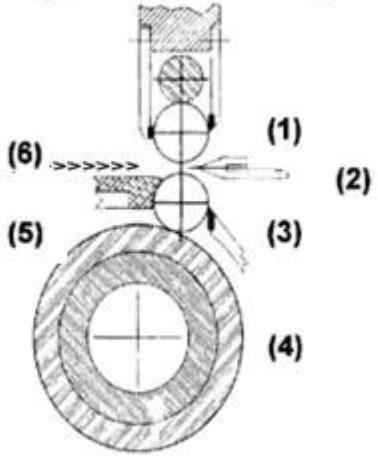
The splitting action.



Presentation: limed splitting operation.

- **The hide is delivered flat grain up on a belt conveyor to the operatives, or via a carefully positioned pallet of limed hides.**
- **The hide slides from the pallet / conveyor onto a stainless steel horizontal work or feed table.**
- **Using the feed table, the hide is presented to transport/grip rollers.**
- **These firmly hold the hide and feed it against a moving band knife blade.**
- **The hide is split into two horizontal layers.**
- **On completion, hide removal is part of the through feed action.**

Detail: two steel transport rollers and splitting blade arrangement.



Presentation: from feed table to transport rollers/band knife.

1) Steel transport roller.
2) The band knife.
3) Ring transport roller: Steel segments each approx. 3cm width free to rotate on a central flexible axle.
4) Support roller: steel covered in rubber.
5) Work or feed table.
6) Hide: grain up.

The support roller allows the steel segments to rise and fall and absorb variations in substance as the hide is fed through the cutting assembly.

The roller assembly evenly compresses the hide for horizontal splitting into two layers.

The upper layer *(grain layer)* is relatively uniform in substance – the flesh split carries irregularities.

Out feed: onto load cell, then conveyor delivery to drum.

Out feed: trimmed/graded flesh splits.

- After splitting, the grain split can be weighed for subsequent chemical processing, then delivered to the designated processing vessel.
- The flesh split, with the irregularities in thickness, may be inspected and trimmed on an out-feed conveyor before removal from the area.
- Limed fleshing, trimming, splitting and transfer of grain and flesh splits is managed mainly as a single production line.
- However, it can operate as batch production in smaller units.

Review:

The variations in substance between the butt, shoulders, neck and belly areas of hides can be rectified by the lime splitting operation. By use of a band knife assembly the splitting machine can split a hide into two horizontal layers.

The most important section is the grain layer to provide accurate substance. The lower layer, termed the flesh split, carries any variation in substance. This can be processed separately to produce lower quality industrial gloving leather, shoe linings, suede leathers and laminates or for other purposes.

Splitting also enables a relaxation of the grain split, leading to a flattening effect and area increase. In addition, the reduced substance enables the chemicals used in subsequent processes to penetrate the hide more rapidly. This can shorten the time required for processing, and minimise both chemical offers and waste.

DELIMING AND BATING PROCESSES

These processes are the final step for the removal of solublised components from within the structure.

This avoids adhesions and fibre bondings in subsequent processing.

Deliming and bating

Lime split hides awaiting delime.

Inspection of delimed/bated hides.

- In the deliming process the split hides are neutralised from alkali to near-neutral conditions.
- This causes the hides to deswell.
- This releases solubilised proteins and fats from within the structure.
- Special enzymes - known as bating agents - are also applied.
- These processes produce a fibre matrix that is free from materials that would otherwise cause fibre adhesions.
- This provides a soft, clean and relaxed collagen structure for subsequent processing.

Review:

The Deliming process:

This is a step in a gradual change from the high pH liming condition towards the low pH acid state that is normal for most tanning methods. Ammonium salts can be used in this process although these are progressively being replaced by carbon dioxide gas and/or auxiliary products to reduce the nitrogen levels in subsequent wastewater treatment.

The Bating process:

Specialised enzymes that best perform at slightly alkali to near neutral pH levels found in deliming are used to modify the protein structure. Deliming and bating processes can be applied in different floats or combined together.

Degreasing actions:

When greasy hides are being processed, green and limed fleshing, and detergents and enzymes used during soaking, liming, deliming and bating all assist in grease removal.

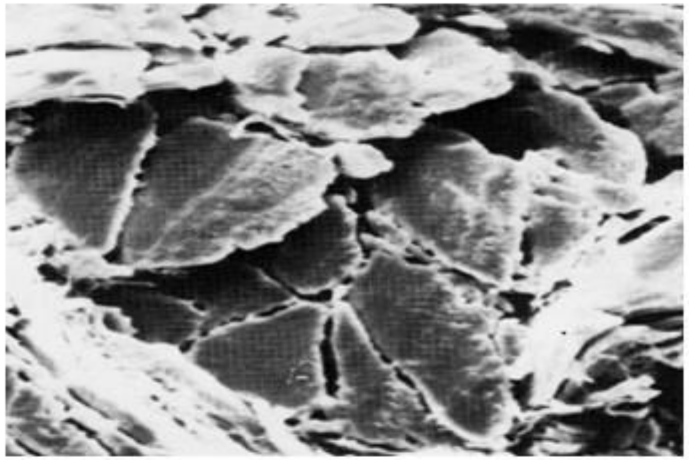
Enzymes applications:

These can target, digest or modify very specific organic components with minimum environmental impact. Their use has been established in leather manufacture to assist the soaking, unhairing/liming, and bating processes via the digestion of non-structural proteins. They also help to rupture fat cell membranes to assist in the release of fat.

These applications are very specific. Enzymes must be used with great care otherwise the sensitive grain layer or the main corium structure can be damaged.

Opening the fibre structure and removal of unwanted components:

Fibre bundles with adhesions.



Well separated fibre bundles.

- If these first stages of processing are not managed correctly, the fibre bundles will not separate and adhesions will occur.
- The final leather will be hard and have a poor break.
- If the fibre bundles are well separated, a soft and flexible leather with good characteristics can be produced.

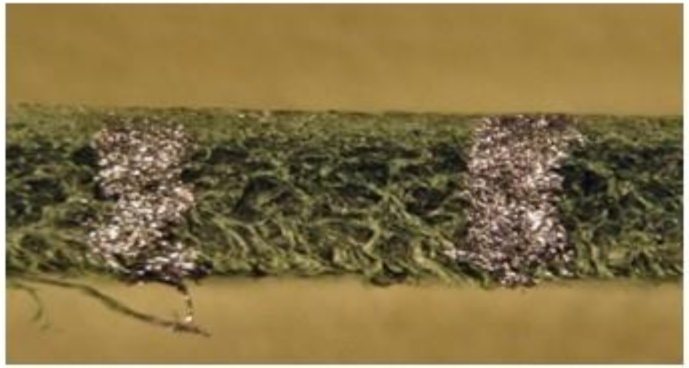
(Images: Credit Betty Haines, BLMRA)

Leather folded grain inwards.

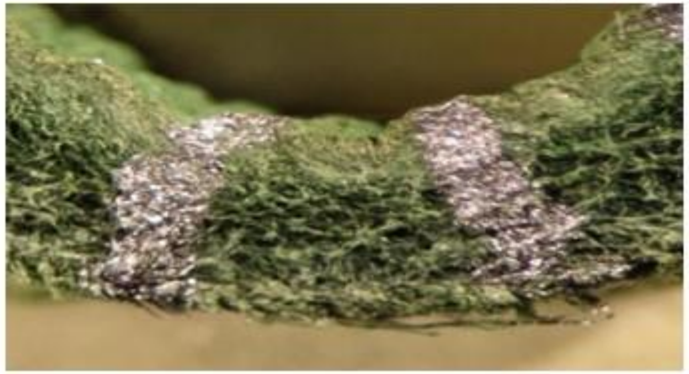
- This fibre separation is essential for the appearance and performance of the final leather.
- It allows free movement within the final leather structure for comfort strength, and appearance.
- It enables good compression of the grain surface and extension of the supporting structure on folding and flexing.

(Images: Credit Betty Haines, BLMRA)

Well separated fibre structure.



Compression of grain and extension of main structure on folding.

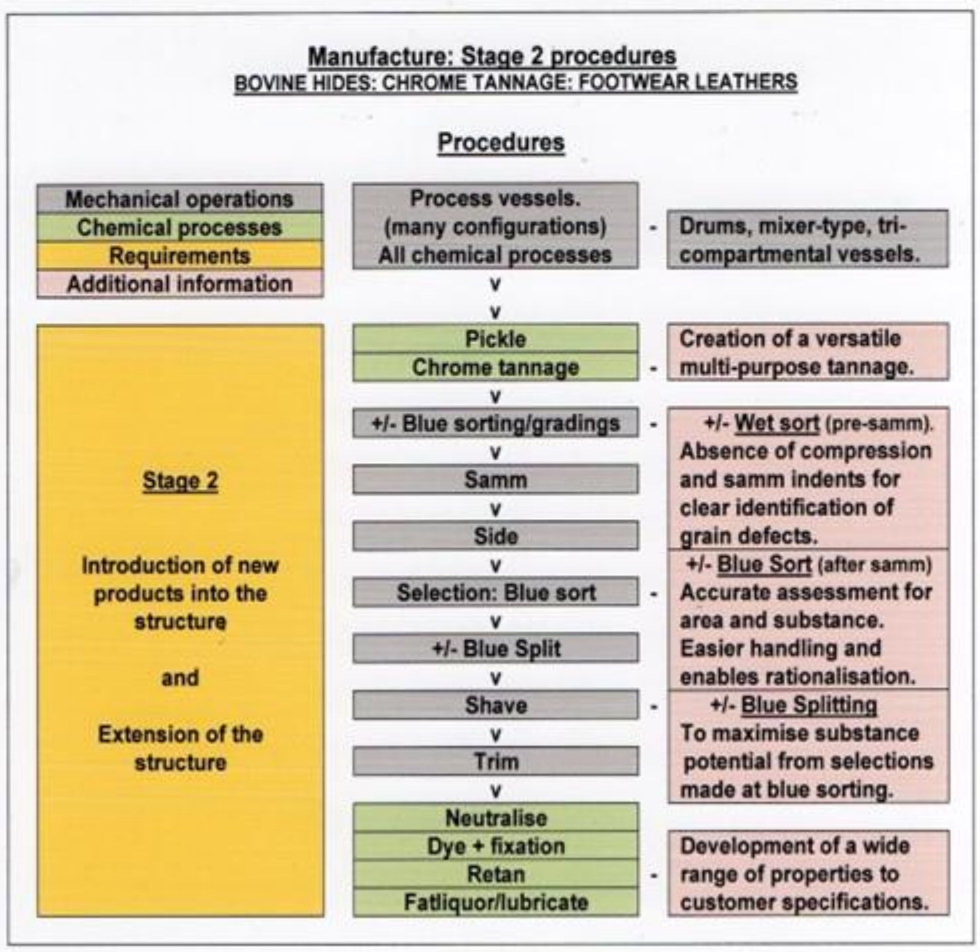


This is also illustrated in the two images where the section markings show that:

- The grain layer can compress on folding, and the supporting fibre structure can expand.
- There is no distortion of the grain or development of coarse folds.
- Structural stress is minimised for long user life as a final product.
- This free movement throughout the fibre structure is made possible in the first stage of making leather.

(Images: Credit Amanda Michel)

Continues as: **"Overview" Part 2**



- **Within Stage 2 procedures, new materials are introduced into the collagen structure.**
- **Controlled additions of chemicals are made to stabilise the structure *(tanning)* and to produce leather.**
- **The leather properties are then amended by further chemical offers in retanning, dyeing and fatliquoring processes, to meet customer specifications.**
- **Extension of the hides and skins from a natural rounded structure to a flattened form continues throughout all mechanical operations.**

(Version: 2024)

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 2)

The introduction of new materials and extension of the structure

Author: Richard P. Daniels

Recommended by:

INTERNATIONAL UNION OF LEATHER TECHNOLOGISTS AND CHEMISTS SOCIETIES

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

This section includes a summary of hides and skins as raw materials.

Part 1: The removal of unwanted materials and extension of the structure.

Part 2: The introduction of new materials and extension of the structure.

Part 3: The removal of water and reconfiguration to a flat form.

Part 4: Application of the finish.

Part 5: Different types of bovine leathers.

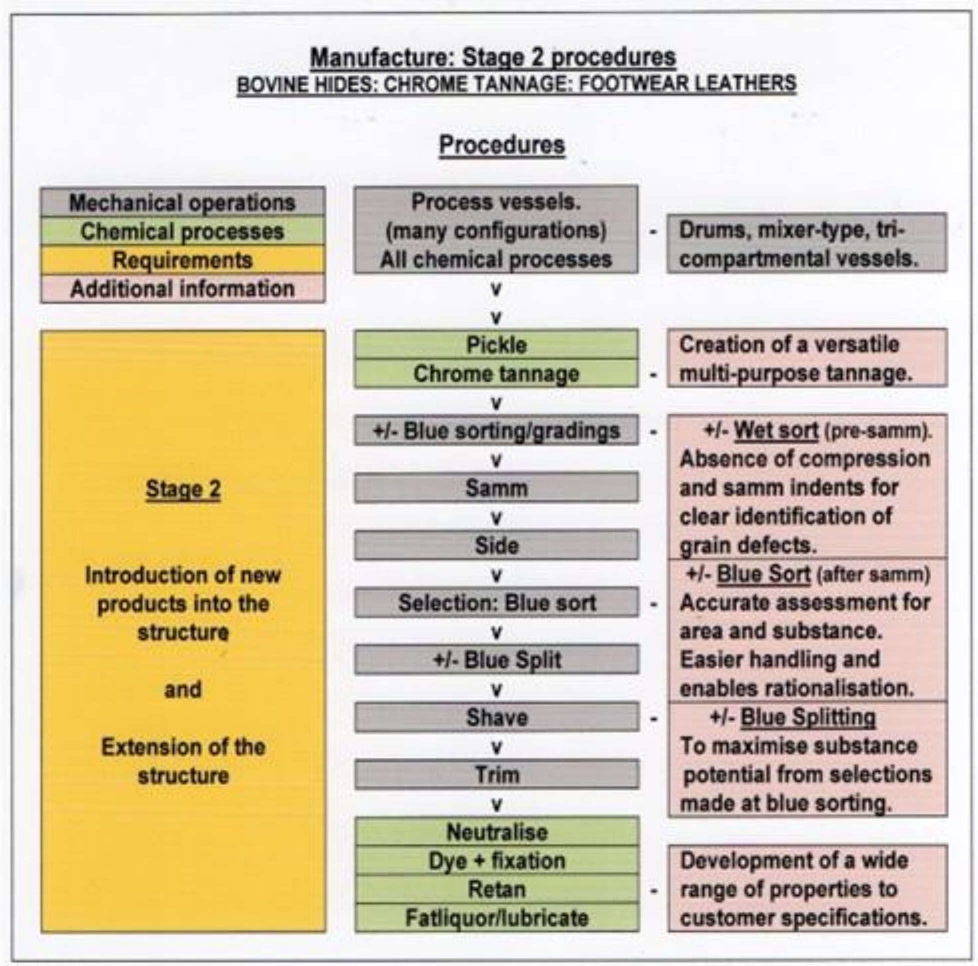
Part 6: Small skins: hair sheep and goat: grain leathers.

Part 7: Small skins: wool bearing sheep: double face, shearling and rugs.

Part 8: Discussion.

Annex.

Stage 2 Procedures



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- **Extension of the hides and skins from a natural rounded structure to a flattened form continues throughout all mechanical operations.**

TANNING PROCESSES

The objective of tanning is to stabilise the collagen structure to provide resistance to putrefaction *(rotting)* under repeated wetting/drying cycles. This chemical processing causes an increase in shrinkage temperature *(Ts)* under high moisture conditions.

Many chemical products can match these technical requirements, but few are able to provide a viable product in terms of aesthetic and physical requirements.

The most common technique is based on chromium salts and is generally known as “chrome tannage”. More than 80% of leathers produced globally are manufactured by this method, and these leathers have been in major use for more than 100 years.

This technique provides hydrothermal stability – wet chrome tanned leathers can withstand boiling in water without irreversible damage – and a leather that can be readily amended in subsequent processing to serve many end uses.

Other important tannages use vegetable extracts, glutaraldehyde-type products, syntans and synthetic variants.

The acid/salt pickle process

Controlled chemical additions.

Acid/salt pickled hides.

- Preparation for chrome tannage involves the addition of pre-diluted acids to delimed/bated hides in the processing vessel.
- Mainly a blend of formic and sulfuric acids, common salt is included to prevent the hides from swelling under the moderately acidic conditions created.
- Known as pickling, this process is part of controlling the penetration of the tanning agent into the skin structure.
- At the end of this process, the hides are neutral coloured, clean and relaxed.

The pickle process is very important in tanning as it controls the chemical reactivity of the collagen structure.

In turn, this determines the rate of the chemical combination of the tanning agent with collagen.

Chrome tanning agents require a moderate level of acidity to penetrate the structure before fixation.

The pickle process is common to most tanning systems, but the level of acidity *(pH)* varies according to the tanning product used.

There are some alternative techniques where the conventional acid/salt pickle is replaced by specialty products, but all tannages need a preparation stage.

The chrome *(chromium based)* tanning processes

Clean and secure conditions.

Tannage complete - awaiting unload.

- Once the acid/salt pickle stage is complete, chromium based tanning agents are added to the process.
- These can penetrate throughout the hide structure, and combine slowly under these conditions.
- Once penetration has been achieved, a mild alkali is added to make the system less acidic.
- Careful control of acidity, in conjunction with the processing temperature, helps the chromium based salts to chemically bond with the protein structure.
- This reaction stabilises the collagen structure and creates chrome tanned leather.

Discharge at end of chrome tannage.

Wet blue - awaiting further processing.

- Once tanned, the hides have developed important properties.
- Known as “wet blue” this tannage is stable, heat resistant, and will not putrefy even if kept in a wet state.
- This type of leather has strong affinity for dyestuffs and other chemicals that can modify the physical and aesthetic properties.
- This leather is very versatile - many different effects and characteristics for different end uses can be developed.

Review:

Chrome tannage is the most common method of tanning. Before the tanning process commences the hides need to be in a moderately acidic state.

(Note: replacement tannages – mainly metal free – are under constant evaluation)

The acid/salt pickle:

When received for pickle/tanning, the hides are mildly alkaline. If chrome tanning agents are added directly then a very rapid fixation will occur on the skin surface. The centre of the hide will remain raw and untanned.

The skins are therefore pre-treated in a process called pickling, generally using sulfuric and formic acid to ensure a controlled tannage. Common salt must also be included to prevent the skins from swelling under these moderately acid conditions.

The pickle/tanning process has a degree of flexibility, so the time and conditions within pickle can vary. Some systems require a uniform level of acidity throughout the structure before the addition of tanning agents. Others need a profile that is more acidic on the grain and flesh layers, but moderate in the centre parts.

Chrome tannage:

Based on chromium sulfate, tanning materials can be supplied in powder form in varying basicities. The more “basic” the chrome, the more rapidly it combines with the skin collagen and the less it penetrates before tanning. The higher the basicity, the plumper, softer and looser the leather produced. Chrome tanning agents can be modified *(masked)* within the tanning operation by other chemicals, usually organic acid salts such as formats. This produces softer and lighter coloured leathers that are less chemically reactive in subsequent processes.

The more acid the skins are within the tanning stage, the slower the reaction between the collagen and the chrome, and the deeper the penetration into the skin structure before fixation. However, after penetration of the chrome through the skin structure - usually by a combination of acid conditions, modification of the reactivity of the chrome tanning product (*masking*), and mechanical action - the tanning system is made slightly less acidic.

This lessening of acidity requires a controlled addition of mild alkalis to increase the fixation of the chromium compounds with the carboxyl groups of the collagen.

The combination of final pH, temperature, and float concentration can provide a high quality product with excellent chrome uptake. The length of time in chemical process between commencing deliming until the end of tannage may be around 15 hours.

Known as wet blue, these leathers are a light blue/green in colour, resistant to putrefaction, and exhibit a shrinkage temperature >100°C when saturated with water. They are chemically very reactive with dyestuffs and the major products used to modify the leather properties in subsequent processes *(neutralising, retanning and fatliquoring procedures – pages 2/38 – 2/50)*

OTHER TANNING SYSTEMS

Three other tannages are considered:

- Systems based on glutaraldehyde.
- White tannages.
- Vegetable tannages - based on a range of vegetable extracts.

The use and importance of these three tannages will change, and similarly to chrome tannages, replacement systems for aldehyde-based tannages are under constant development.

New systems will evolve, but the techniques described provides broad guidance into the methodology of all tanning systems.

The "white" glutaraldehyde tanning process

"White" glutaraldehyde tanned leather.

Required: durable & shape retention.

- This is the first tannage specifically developed as an alternative to chrome tannage - mainly for uses within the automotive sector.
- Requires acid/salt pickling systems similar to chrome tannage, with a rise in pH/temperature to achieve fixation.
- Product available in modified forms to assist structural penetration, and to lighten the pale yellow-brown colour.
- Needs syntans/resins in tannage for shape retention during shaving.
- Leathers can be soft, shrinkage temperature approximately 75C, but little filling within the fibre structure.
- Poor reactivity with dyestuffs and agents used in subsequent processes.

White tannages

"White tannages" - variety of shades.

Various properties - can be very soft and tactile.

- There are many "white" tannages.
- These have mainly been developed as replacements for glutaraldehyde tannage.
- These are based on a variety of products - syntans, "colourless dyestuffs", cross-linkage systems - and other organic and non-organic products.
- Process techniques often similar to glutaraldehyde tannage employing an acid/salt pickle, but some can commence at a higher pH.
- Mainly need additional products in tannage for shape stability and retention.
- Often reduced reactivity with products required in retannage and fatliquoring.

Vegetable tanning processes

Light leather – wet relaxed and pliable.

Heavy leather – wet firm and compact.

Long established methods, where extracts from barks, leaves and fruits are used to make two types of leather:

1] ***"Light leathers"*** – low substance, with a moderate level of tanning content for medium softness.

Shown stacked after drum tannage.

End-uses: footwear and leather goods.

2] ***"Heavy leathers"*** – high substance with high level of tanning content for dense filling and great durability.

Shown draining after a "pit" tannage - sufficiently firm and compact to stand on shanks without any support !

End-uses: Soles/lining for footwear, belts, harness, industrial and carving.

Veg extract addition in drum tannage.

Movement of hides during pit tannage.

Light leather manufacture: uses low offers of vegetable tannin extracts with fast drum processes. Employs acid/salt pickles of weak acidity.

Heavy leather manufacture: uses high offers of extract and can take 4 – 10 days.

- Tannages managed by moving hides suspended on frames through a series of pits of tannin solutions of increasing concentration.
- Drum/pit combinations, and sometimes drums only.
- Various pre-treatments before tannage.

Review:

Glutaraldehyde tannages:

It is possible to make very soft leathers, but tannages are generally performed in combination with syntans/resins to provide shape stability during shaving.

Offers of fatliquor are also needed for a progressive development of softness throughout the structure. The processing time can be similar to chrome tannage, but because the tannage produces an anionic charge *(negative change)* in the structure, stacking periods at the end of tannage are common to improve the fixation of anionic syntans/resins/fatliquors.

"White tannages":

As replacements for glutaraldehyde tannage, these tend to be similar in physical properties, with the colourations ranging between white and light yellow/brown. When fully processed – supported by high offers of syntans, resins, and vegetable tannins in retannage - they can provide high shape retention and good ageing properties.

Automotive and aircraft seating, interior mouldings and rail-carriage uses. Light in weight, durable and easy-clean for good hygiene in heavy use situations.

Vegetable tannages:

These are based on soluble extracts from shredded bark, wood, leaves and the fruits of various trees and bushes. These are leached with water, with the extracts spray dried to form a powder. The source of the extract gives each type of vegetable tannin a distinct character and this is reflected in the final leather produced in terms of colour, plumpness, tightness and firmness. These extracts may be chemically modified, to increase the tannin solubility and produce a lighter colour.

To help achieve the required leather characteristics it is usual to blend several types of extract together. The most common extracts are mimosa, quebracho, chestnut, and tara, although there are many other products available.

The solutions have a colloidal nature and contain tannins in a range of particle sizes. The smaller molecular clusters penetrate the skin rapidly and help disperse the larger particles. The smaller clusters possess weak tanning properties generating thin leather, whereas larger particles penetrate more slowly, causing more filling between the fibres within the structure.

The process in its simplest form has been established over many centuries. Originally performed in pits where hides inter-layered with chipped bark were stacked, a slow tannage developed as tannins leached into solution.

Pickle systems are very weakly acidic when compared to chrome tannage, or may involve other forms of pre-treatment.

Two types of vegetable tanned leathers are made.

Light leathers:

Tannages use relatively low offers of selected vegetable extracts when compared to heavy leathers. These are usually drum processed and managed on a one-day cycle. Soft, moderately filled with good shape retention, these are used for a range of leathers including shoe upper and lining leathers and small leather goods. Colour - pale to medium brown.

They provide a high level of comfort in footwear, and hygiene advantage due to the anti-bacterial properties of vegetable tanning agents.

Heavy leathers:

These are very firm, dense and heavy duty leathers, often processed using pit tannages. These systems are part-mechanised where the hides suspended on frames are introduced into solutions of increasing concentration. This keeps the pieces separate, but because these systems are essentially static the penetration of tannins is very slow at 10 days (+/-) according to product. Combinations of drum and pit systems are used to shorten/rationalise manufacture to 4 – 10 days. Drum- based tannages are used too, although the fibre density acquired by pit systems is not achieved.

These leathers are for heavy duty uses such as embossing, carving, saddles, belting, craft, footwear components, and some industrial purposes where they provide superb shape retention.

These different characteristics of tannages are summarised

Panel 1 — *"Overview"© R.P.Daniels*

Characteristics of different tannages

Tannage	Properties of dried leathers (tanned only)	Shrinkage temperature (saturated) and Charge	Dyeing, retanning and fatliquoring. (anionic products)	Properties of final leathers and End uses
Chrome	Blue-green colour. Hard and thin.	100C. Cationic	Good dye properties. High uptake of retanning agents and fatliquors.	Very versatile. Very soft to firm. Footwear, auto, furniture, bags, leather goods etc.
Glutaraldehyde	Light yellow brown colour. Soft to medium. Thin with poor retention of shape unless heavily supported by syntans/resins.	Approx 75C. Anionic	Poor dye properties. Poor uptake of retanning agents and fatliquors.	Very soft to firm. Good aging properties. Auto use – mouldings and seats if heavily retanned. Footwear, upholstery.
Other tannages (Many options)	White to pastel colours range. Moderately soft / firm.	75C – 85C. Anionic	Poor dye properties. Lower requirements for retanning agents and fatliquors.	Soft to firm. Many variations, with mainly glutaraldehyde – type properties.
Light vegetable	Cream to light brown colour. Moderately soft.	Approx. 85C. Anionic	Poor dye properties. Low requirement for retanning agents and fatliquors.	Soft to firm with good shape retention. Well filled leather suited for shoe linings and leather goods. Anti-bacterial properties and warm handle.
Heavy vegetable	Light to red-brown. Firm, with dense structure.	Approx. 85C. Anionic	Dyeing and retannage mainly not required.	Offers excellent shape retention. Suited for soling, harness, belts, moulding and carving.

Note:

- Information for general guidance only.

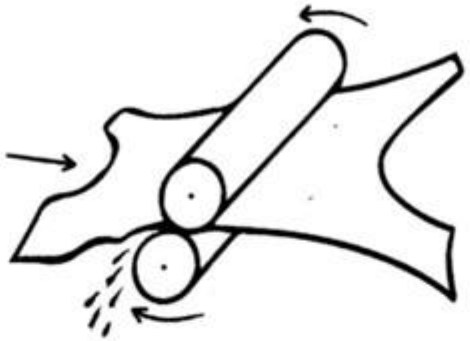
SAMMING, GRADING, SPLITTING AND SHAVING OPERATIONS

After tannage the leathers carry significant variations in substance and quality.

Assessment and grading are required, and substance adjustment for specified end use.

The samming operation *(through-feed action)*

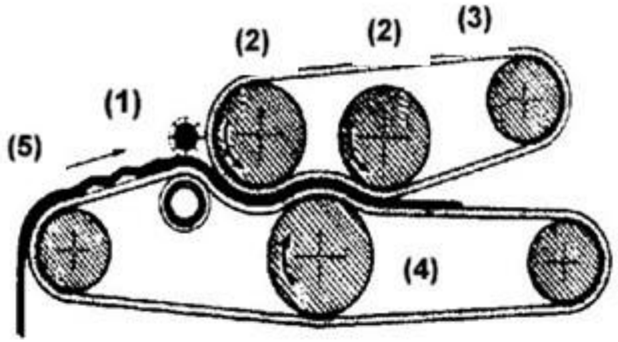
The basic samming action.



Presentation: the samming operation.

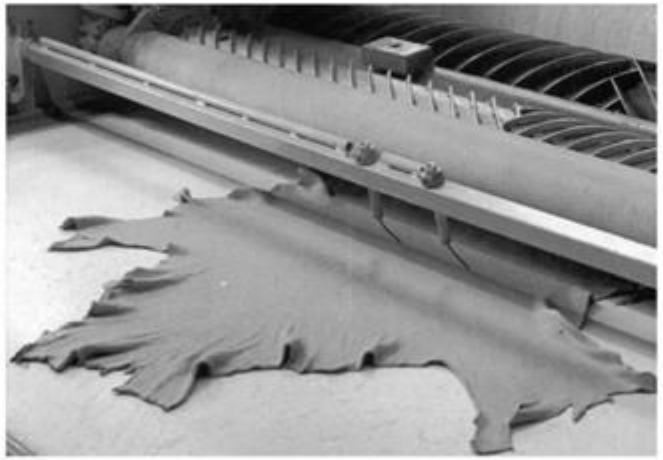
- After tanning, the wet leather is lightly squeezed to flatten and part-dewater the structure.
- Leather is presented grain up in this operation.
- Variations in cross hide substance are accommodated by dewatering felts fitted over the pressure rollers.
- If hides have not been limed split, these variations can be considerable.

General assembly showing rollers and dewatering felt arrangement.



1) Spread *(or setting)* roller.
2) Upper pressure rollers.
3) Felt dewatering belt.
4) Main pressure roller.
5) Leather: grain up – samming action as a through feed operation.

Feed to the spread roller.



The spread roller extends the hide before the samming action commences.

Gentle pressure is applied in the samming action to squeeze water from the leather.

A compact and uniform structure is required for good shape retention during the shaving operation.

(Image: credit unknown)

Presentation: hides ”floated” in water.

Delivery of hides by line conveyor.

- After tanning, hides are often down loaded from drums into trucks or containers that hold both the hides and water.
- The buoyancy provided eases the handling for the feed operatives.
- This “floating” also prevents creasing and uneven compression of the hides at the bottom of the hide mass.
- Hides can also be dumped beneath the processing vessels, then delivered by line conveyor to the samming operation.
- Leathers are usually transported away from the samming operation on a belt conveyor.

Sorting and siding arrangements

Siding after blue samming operation.

Sammed/sided hides awaiting selection.

- For footwear leathers, hides are usually cut along the backbone *(siding)* to produce two sides.
- Each side can then be assessed separately for grain quality and potential instead of the whole hide.
- There can be technical advantages in processing whole hides. However, a combination of tradition and grain selection advantages has resulted in side manufacture from the tanned state for footwear leather.

Splitting in the tanned wet blue state

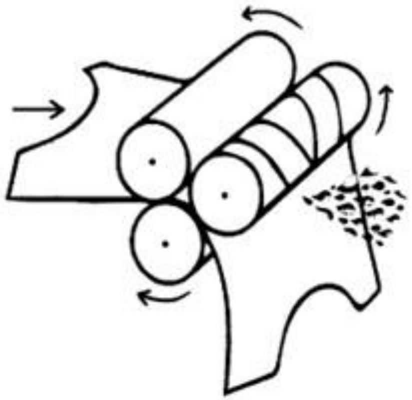
Angled-jack assist for optimum presentation.

Siding can also take place after blue splitting to produce a larger flesh split.

- The splitting operation can take place after samming instead of in the limed state.
- The operation is similar, but the machines are slightly modified.
- Sammed leather is easier to handle, and the grain layer is more uniform in substance.
- It also offers the widest substance selection.
- The substance can also be very close to the shaving substance, hence less waste.

The shaving operation *(in-feed action)*

The basic shaving action.

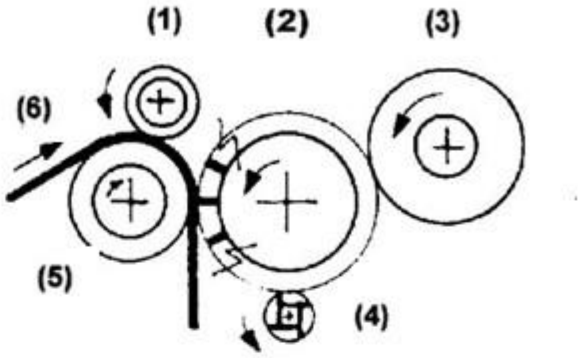


Presentation: the shaving operation.

The butt part is presented grain down using a feed roller *(or table)*.

- On in-feed, a small amount of the substrate is cut from the butt structure.
- The machine is re-opened, the leather turned, and operation repeated on the neck area.
- On completion, the machine is opened by the operatives for leather removal.
- Care is required at the time of in-feed to prevent cutting damage to peripheral parts.
- This operation can be managed by one person, but often a second is employed to minimise damage to the shanks.

General roller / shaving cylinder assembly.



Cylinder mounted cutting blades.

1) Transport roller.
2) Bladed shaving cylinder.
3) Grind stone.
4) Deflection roller *(anti-wrap rotor).*
5) Transport roller rubber coated.
6) Leather: grain down – shaving action as in-feed operation.

The angle of the cutting blades ensures that the leather is stretched and extended from the centre of the piece at the time of cutting.

This flattened structure improves the grain appearance and quality.

Blue trimming

Trimming away machine damaged parts.

Often managed in conjunction with the shaving operation.

- To minimise damage, leathers are extended when presented to the shaving operations.
- However, there is often cutting damage, especially in shank parts.
- The damaged edge is cut away to avoid tangling and tearing in following processes and operations.
- This may take place after shaving a full batch as a separate operation.
- It can also be team-managed.
- Here, once shaved, each piece is dropped onto a table for trimming.
- Similarly, trimming can be performed on a belt conveyor.

Review:

Samming operation:

After tannage, the leather is unloaded from the processing vessel, and surplus water squeezed from the hides or skins. This is generally a through-feed operation that combines a pre-stretching action known as setting before the main squeezing action to press water from the structure.

Hides and skins tend to form pleats and folds in the peripheral parts, especially the fore shanks and hind shank areas. If the setting action does not extend these parts before compression, then creases will form that will then be sliced or chopped on blue splitting *(if performed)* and shaving, causing a loss in usable area.

The dewatering action relies on a slow feed with relatively gentle compression to avoid distortions through the vertical hide section. The hides presented are not uniform in thickness, and the water retained within the structure will vary due to cross-hide differences. The uniformity of outcome is highly dependent upon the choice of dewatering felts used in the assembly. A well extended crease-free structure is required, with uniform cross-hide moisture content and compression to ensure shape stability on shaving *(+/- splitting)*. It is also important to avoid felt indentations in the grain surface due to over compression.

The key intent is to provide leathers with consistent physical properties to the shaving operation *(+/- splitting)* so that these machines can function at their optimum settings. If leathers are insufficiently compacted or too soft, they will not retain their shape, resulting in gouging and cutting damage. If the outcome is too dry, over compressed or hard, then cutting damage will occur and the leathers at the end of manufacture may be too high in substance.

Grading and selections:

One of the objectives of the tanning process is to make a consistent product that can be used for a variety of different purposes. On selection, the suitability and potential for different uses can be ascertained. This includes grain quality and appearance, potential substance and area.

If leathers are graded as whole hides without limed splitting, then there is the potential of gaining a large flesh side split for other purposes. If these hides are split down the backbone after samming *(siding)*, the splits will be of less value, but each half of the hide can be graded with the opportunity of improved overall selections.

Siding:

This is common practice for shoe upper leather manufacture as the components required by the footwear manufacturer tend to be relatively small in size.

Splitting in the tanned state:

Limed splitting may have been omitted and in this event the leather is split in the wet blue sammed state.

Advantages include the widest possible selections for substance, and splitting close to the shaving substance. This means little loss of substrate as shavings, and maximum potential for the substance of the flesh split. The flesh section contains the irregularities in substance, but can be shaved to an accurate substance for suede-type use or finishing with heavy surface coating.

Shaving operations:

The thickness is slightly reduced in this precision operation where leather substrate is cut from the inner section of the skin. This cutting is provided by the action of very sharp, spiral knives mounted on a rotating cylinder. The piece is extended at the time of cutting by the angled blades to produce a very uniform and accurate final substance *(accurate to 0.1mm)*. It also provides a flat, extended and smooth grain layer.

Trimming operations:

Trimming is normally performed to remove torn parts after shaving. This damage usually occurs during in-feed to shaving as it is difficult to fully extend the shanks at time of offer. There may also be some previous damage caused by blue splitting and this is often compounded in shaving. This removal should be minimal to avoid losses of usable/saleable area.

Trimming helps to prevent tangling in dyeing/retanning and fatliquoring, and subsequent poor chemical distribution and staining. It also helps to avoid tearing in subsequent machine operations.

NEUTRALISATION, RETANNING, DYEING AND FATLIQUORING PROCESSES.

The tanning process provides leather with distinct properties, but requires considerable modification to meet specifications and properties required by the end-users.

Considerable change can be provided by further chemical processing to the shaved hides in the neutralisation, dyeing, retanning and fatliquoring processes.

Preparation for neutralising, dye, retan, and fatliquoring

Avoiding drying between operations.

Water use: close control of both volume and temperature.

- After shaving and trimming to remove any damaged parts, the damp leather is weighed.
- All chemical additions are based on this weight.
- Between shaving and drum processing the leathers are often sealed in cling film or polythene to prevent drying of the structure.
- After loading the drum – often manually to ensure that each piece is fully open and separate – the leather is fully saturated and washed before the neutralisation process commences.

The neutralisation process

Clean conditions for consistency.

Checking cross-section for pH.

- In this stage the wet blue leather is made less reactive to dyestuffs, retanning and fatliquoring products.
- This involves lowering the acidity *(raising the pH)* of the wet blue using mild alkalis.
- The depth of this "neutralisation" within the section helps control the depth of penetration of subsequent product additions.
- The neutralisation process is checked by monitoring the pH of the float and inspection of the cut section with pH indicators *(colour sensitive)* to gauge the degree of penetration.

The dyeing process

Dye penetration – mainly determined by neutralising and dye properties.

Pre-weighed dyes awaiting offer.

- Dyestuffs are used to create almost any colour - light pastel to intense dark shades.
- Dyeings may be limited to the surface, or may penetrate completely through the structure.
- There are many different types of dyestuffs available.
- These can be added to process in the powder form, or pre-dissolved in water.
- The fixation at the end of the process may be controlled by pH adjustment, or by use of selected fixatives.

The retanning process

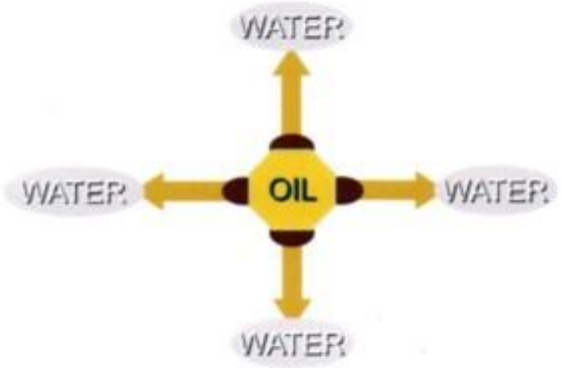
Processes: performed manually.

Processes: computer managed.

- Various retanning agents are added to fill the structural voids as required within the fibre structure and create special effects.
- These are both natural and synthetic based products.
- The amounts offered to process and choice of retanning agent vary according to the degree of support and filling required within the structure.
- These additions are often manual, but very sophisticated equipment can be used to measure and add chemicals.

The fatliquoring process

Oil in emulsion in water.



Oil + water, and a stable oil emulsion.

- Fatliquors are non-miscible oils that have been modified to form a stable emulsion in water.
- The oils/fats and the techniques used in fatliquor manufacture have a strong influence on leather softness and handle.
- These are mainly added as an emulsion after retannage and dyeing.
- The emulsions penetrate and then split to deposit oils into the leather structure.
- These lubricate the fibre to reduce fibre adhesions on drying.

(Images: Credit unknown)

Review:

It is not possible to build the exact properties required into the leathers during the tanning operation. It is practice to develop the leather character by further wet processing of the shaved hides.

Neutralisation:

This treatment prepares the leather for dyeing, retanning, and softening. In this first part of often complex processing, mild alkalis are added to the leather to reduce the moderate acidity of the leather. This is to enable deep penetration of reactive chemicals and agents into the leather structure in subsequent processes. The reactivity of the leather can also be modified by including masking agents such as formates, and specialised products of low molecular size known as auxiliary syntans.

The dyeing process:

There are many types of dyestuffs but anionic dyes are the most frequently used. Acid and direct dyes are used for penetration, surface dyeings and selected fastness properties, while 1:2 premetallised dyes are mainly used for light fastness.

Whole ranges of colour are covered by these dyestuffs and the tanner is able to colour match accurately to a pattern. The dye can be added to the processing vessel either pre-dissolved or as a dry powder.

The dyeing process can be on neutralised leather, or after a suitable retannage. Several additions can be made according to the intensity of colour required or dye penetration into the leather. The dyes are usually fixed by acidification or the use of specialised fixatives.

Sometimes specialised pigments are included, mainly for black and white leathers.

The retanning process:

Selected materials are applied to the neutralised leather to combine with and modify the leather structure. Normally these products are vegetable tanning materials, synthetic tanning agents *(syntans)*, acrylic resins and fillers. These provide very specific properties to the final leather, and several different retanning agents are normally used together. Their combined effects can make the leather feel softer and fuller.

Objectives include selective filling of the grain, the junction between the grain and corium, and deep into the main corium structure. They can also target the belly parts as these contain more voids than the butt parts, where they can provide more filling. This improves the cross-side uniformity and shape retention/stability between the areas of different fibre density and structure.

This is part of creating a more consistent product, a defined leather break, and a uniform grain structure in preparation for finishing operations.

It is noted that the colour and intensity developed on dyeing is changed by retannage. This needs taking into account in the dyeing procedures and may affect the choice of retanning agents where pastel shades are required.

Retanning materials provide leather softening by filling spaces within the leather structure and moderate adhesions that develop within the fibre structure on drying. Fatliquors are used to lubricate those fibres:

The fatliquoring process:

A fatliquor is an oil chemically treated so that it will emulsify with water to penetrate and lubricate the leather fibre structure. The deeper this penetration, and the greater the offer, the softer the leather, but the greater the tendency to develop a coarse break.

Leather making properties are strongly dependent upon the raw oils used - synthetic, fish, vegetable, animal, tallow and even greases. These oils may be sulfonated or sulfited to ensure good emulsification.

Fatliquors strongly influence the final characteristics of leathers, and can provide a degree of filling within the structure too.

A leather with a soft, plump chrome tannage will not require as much fatliquor as leather produced by a firm tannage.

Polymeric softening products:

Water soluble acrylic polymers of high molecular weight are often used for retanning, but are also modified for leather softening. These products can be made chemically active to combine with collagen, providing good light fastness, heat resistance and improved physical properties. In practice they are used in combination with reduced offers of fatliquors.

Waterproofing agents:

Modified acrylic polymers with long molecular side chains can be used to both soften and develop waterproofing properties in suitably prepared leathers. These products often incorporate silicon in their structure, but under carefully controlled conditions can form an emulsion in water and penetrate the leather structure. Acidification deactivates the emulsion, and the water repellent properties are normally achieved by chrome fixation.

Special effects:

Specific properties can be introduced in the retanning/fatliquoring sequences. For heavy duty walking boots, hot waxes and grease can be drummed into the leather. Complete dye penetration or two-tone effects can be managed. As part of specialised production, very level dyeings are possible by processing the leather to the dry state *(crust state)*, then, after sorting and grading, re-wetting and re-dyeing.

Process variations:

The sequence of these process stages can be altered. Fatliquors can be added both before and during retannage. Sometimes neutralisation and dyeing are performed together, and can include retanning agents. Different floats can be used with each process stage, or multi-addition processes used.

Different tanning systems:

Other tanning systems have different requirements within retannage and fatliquoring than are required by chrome tanned bovine leathers.

Heavily vegetable tanned leathers need little or no retannage as the structural filling in tannage and the development of characteristics in tannage is considerable. They may only need a light surface lubrication to improve the grain.

Lightly vegetable tanned leathers can be retanned to change their characteristic and provide more filling within the fibre structure.

They will need some fatliquor offer for lubrication and softness, but less than required for chrome tanned leathers at the same thickness.

Glutaraldehyde and wet white leathers may be supported in the tanning system by syntans and resins to provide the shape stability required during shaving. However, further applications are needed in retannage to sufficiently fill the structure. Fatliquors may be used in the tanning stage, but further additions will be needed in conjunction with retannage to produce softness.

When making leathers based on wet-white tannages, more retanning and fatliquoring products are needed than required by chrome tanned leathers at the same substance to produce leathers with similar tactile properties.

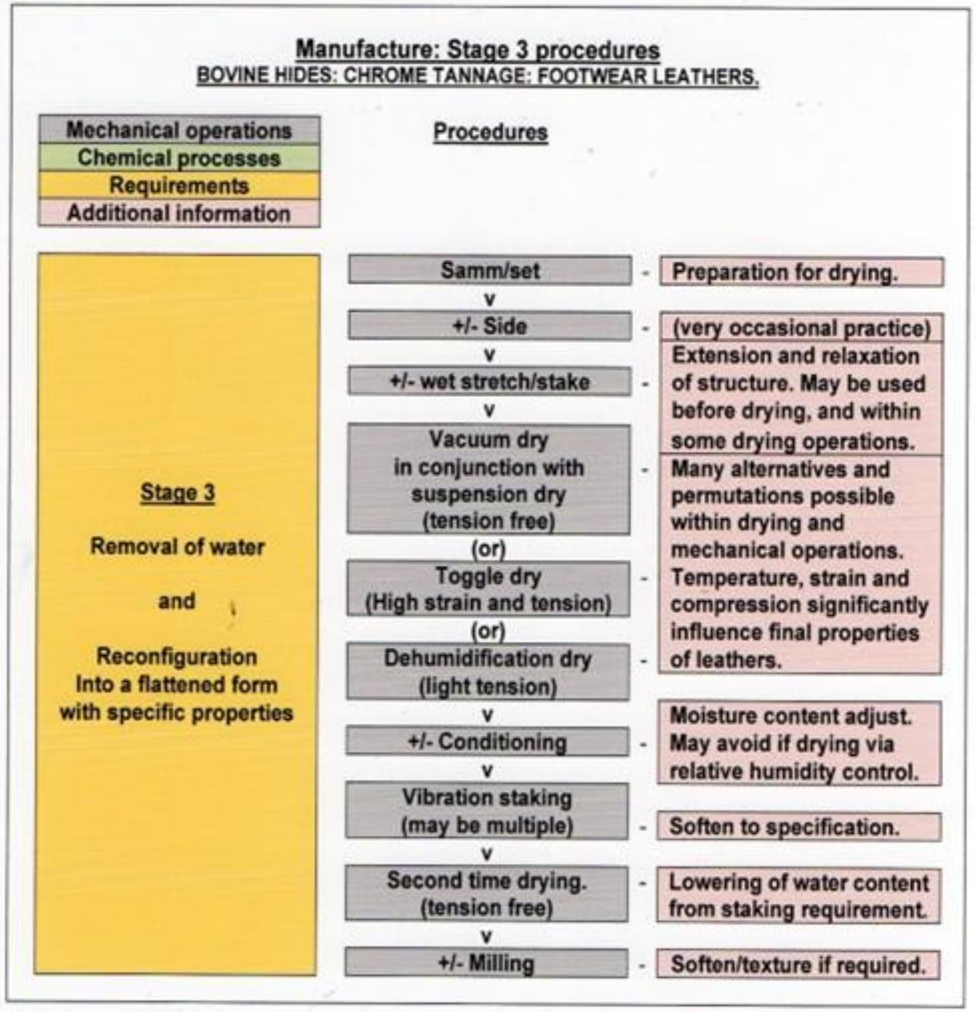
The cationic charge *(positive charge)* of chrome tanned leathers enables a high fixation of the mainly anionic products in retanning and fatliquoring. An anionic charged wet white does not enable such a high degree of fixation, so the offers of retanning and fatliquoring products are significantly greater.

If systems are developed for a wet-white tannage with a strong cationic charge, then uptake of these anionic products will be improved.

Wide range of uses and properties.

- Stabilising materials are introduced into the collagen structure in the tanning process.
- Retanning and fatliquoring agents are then applied to make a wide range of leathers.
- From durable work boots where the tough comfortable leather uppers outlast the soles - to elegant fashion leathers for men and women.
- And, of high importance, footwear designed to meet the growing needs of children.
- An extraordinary range of products !

Continues as: **"Overview" Part 3**



- **Within Stage 3 procedures, water is removed from the structure to produce dry leather.**
- **The mechanical operations used in preparation for drying, followed by water removal by evaporation, produce a flat and useful substrate.**
- **The outcome from processes and operations used in Stages 1 and 2, are mainly completed within Stage 3 procedures.**
- **The extension of hides and skins from a natural rounded structure to a flattened form is made complete, providing very specific properties to the structure.**

(Version: 2024)

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 3)

The removal of water and reconfiguration to a flat form

Author: Richard P. Daniels

Recommended by:

INTERNATIONAL UNION OF LEATHER TECHNOLOGISTS AND CHEMISTS SOCIETIES

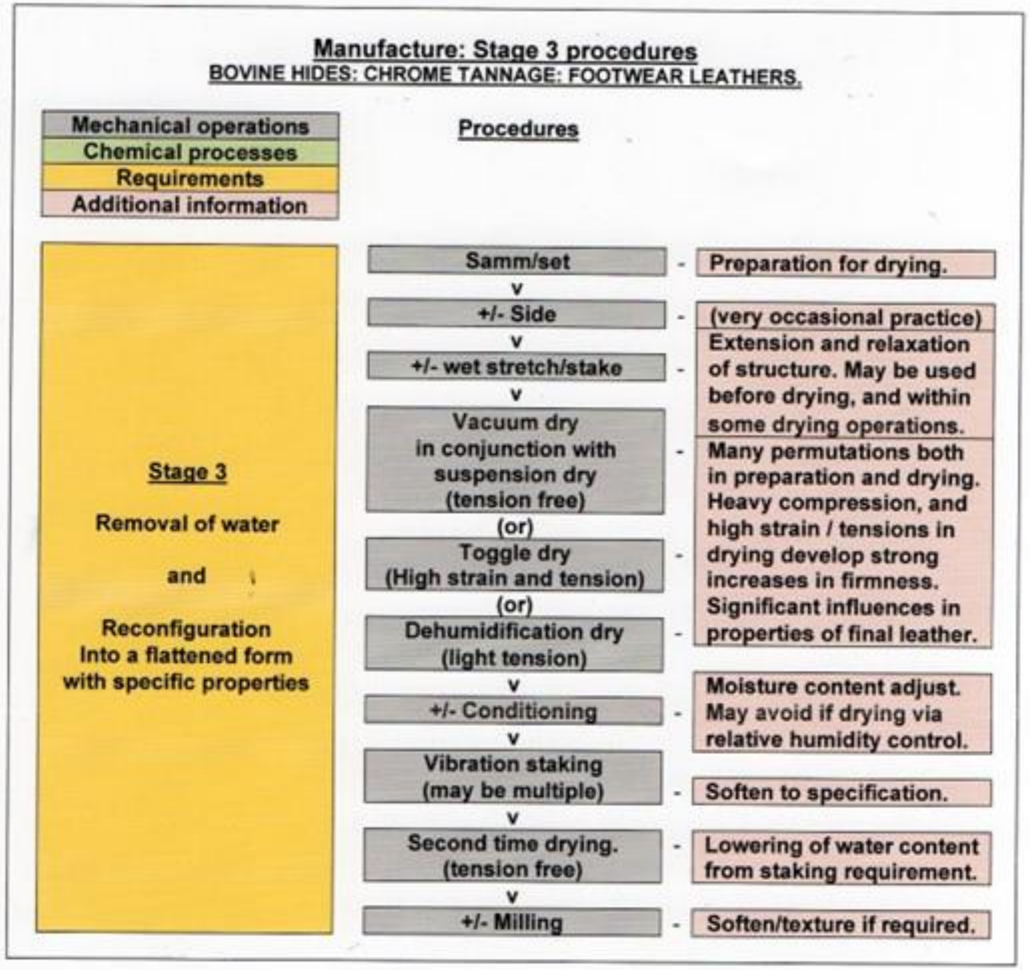
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

This section includes a summary of hides and skins as raw materials.

Stage 3 procedures



- Within Stage 3 procedures, water is removed from the structure.
- The mechanical operations used in preparation as part of this drying, followed by water removal by evaporation, produces a flat and useful substrate.
- The outcome of processes and operations used in Stages 1 and 2, are mainly completed within Stage 3 procedures.
- The extension of hides and skins from a natural rounded structure to a flattened form is finalised, providing very specific properties to the structure.

PREPARATION FOR DRYING

After retanning and fatliquoring processes, part of the water is removed mechanically from the structure in the samm/setting operation. This compresses and extends the structure, and flattens the grain surface for presentation to the main drying operations.

This compression and extension strongly affects the orientation of the fibre structure and, in turn, this influences the outcome from evaporation drying.

If pre-drying mechanical operations are not carefully managed, there can be significant variations in softness, the fineness of break, looseness and yield of the final leathers.

Pre-drying procedures

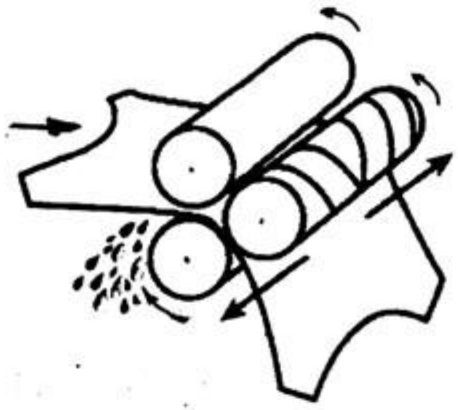
Sides discharge into steel containers.

Hand stacking leathers for draining.

- On completion of neutralisation, dyeing, retanning and fatliquoring processes, the leather is washed.
- This is to remove residual products and neutral salts from the structure.
- The drums are then unloaded, often into stainless steel containers.
- Leather can be stacked and drained before presentation to machine operations.
- Alternatively, the leather may be stacked flat in a container and covered in water to minimise pressure on pieces at the bottom of the pile.

The samm/setting operation

The basic samm/set action.

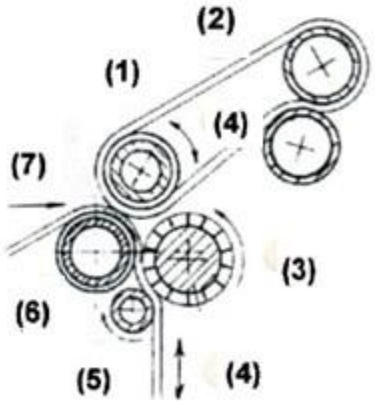


Presentation: the samm/setting operation.

- Leather is offered to the operation grain up.
- A strong setting action stretches out any creases before dewatering.
- The samming action gently squeezes water from the leather.
- It also compresses and consolidates the extended structure.
- There are many machine designs.
- Two diagrams are given for example.

Samm/set machine *(return action)*

The cylinder/felt arrangement.



Turning leather after samm/set of butt area.

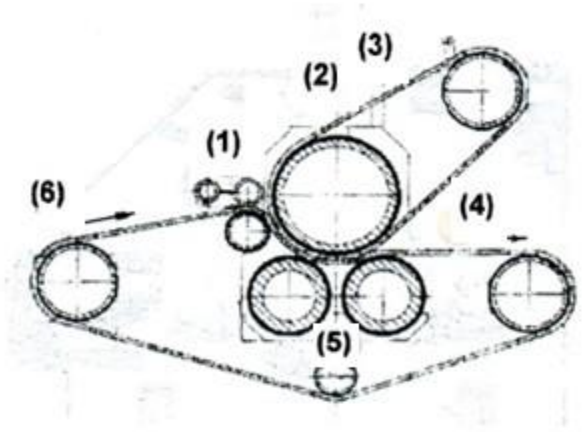
1) Upper pressure roller.
2) Felt dewatering belt *(may be felt roller only).*
3) Bladed setting cylinder.
4) Forward/reverse actions.
5) Anti-wrap rotor.
6) Support roller.
7) Leather grain up - samm/set action by forward/reverse movement.

Samm/set butt half, then turn by operatives and samm/set neck part.

Return action by operatives to complete cycle, with stacking for batch processing.

The samm/setting machine *(through-feed action)*

Three roller through-feed arrangement.



1) Bladed spread roller assembly.
2) Upper pressure roller.
3) Upper felt dewatering belt.
4) Lower felt dewatering belt.
5) Support/pressure rollers.
6) Leather grain up - samm/set action by forward/reverse movement.

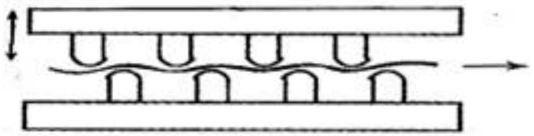
Presentation: samm/set operation.

The leather is conveyed flat and extended from the operation.

When part of line production, out-feed may be directly to the next operation.

The wet staking/stretching operation *(through-feed action)*

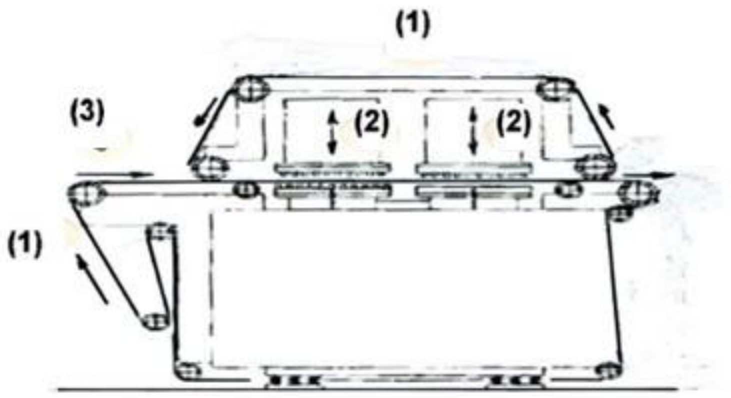
Basic wet staking/stretching action.



Samm/set - conveyor delivery to wet stretch/stake operation.

- **Leather is conveyed between twin belts and flexed/stretched using pins set on vibrating pressure plates.**
  (This operation was introduced to leather manufacture in the 2000s. The machine design is essentially as the vibration staking machine (page 3/27) used since 1960s. Major actions within these variations are the same, but with refinement in pin size and movement.)
- **These pins are larger in diameter than fitted to the conventional vibration staking machine, and provide an enhanced stretching action.**
- **Feed is often by conveyor after a through-feed samm/setting to this operation.**

The wet stretch/wet staking machine.



Off-take with manual stacking.

1) Flexible conveyor belts for transport of leather through machine.
2) Oscillating rounded steel pins for fibre separation and stretching action.
3) Leather offer grain up, movement as a through-feed operation.

- The pin action both flexes and extends the damp compressed structure.
- An overall loosening of the fibre matrix provides a softer leather.
- This loosening assists the release of moisture on evaporation drying.

Review:

Samm/setting operation:

After the retanning, dyeing and fatliquoring processes, the leathers are stacked in preparation for the mechanical removal of creases and excess water. This may enable some drainage of water from the leathers, but often leathers are stacked flat and immersed in water. This ensures a uniform saturation of leather throughout the batch, and minimises pressure on pieces at the bottom of the pile.

The most common pretreatment before drying is the samm/setting operation. This combines a light samming action with a strong setting or stretching action.

Wet stretching/staking operation:

This can follow the samm/setting operation. It reduces any over-compression from the samming action, and loosens the fibre structure. The stretching action extends the leather with area increase and reduction of grain indentations from samming felts for improved appearance. The fibre loosening appears to improve the release of water from the structure.

The wet staking/stretching machine was developed in the 2000s. The action is similar to the feed-through vibration staking machine used for mechanically softening dried leathers.

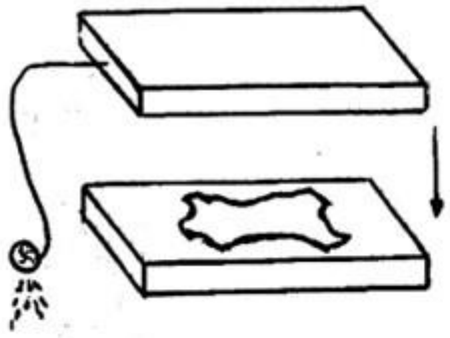
PREPARATION FOR DRYING.

For bovine chrome tanned shoe upper leathers there are four major options for evaporation drying:

1] Vacuum drying.
2] Suspension drying.
3] Toggle drying.
4] Dehumidification drying.

1] The vacuum drying operation:

The vacuum drying operation.

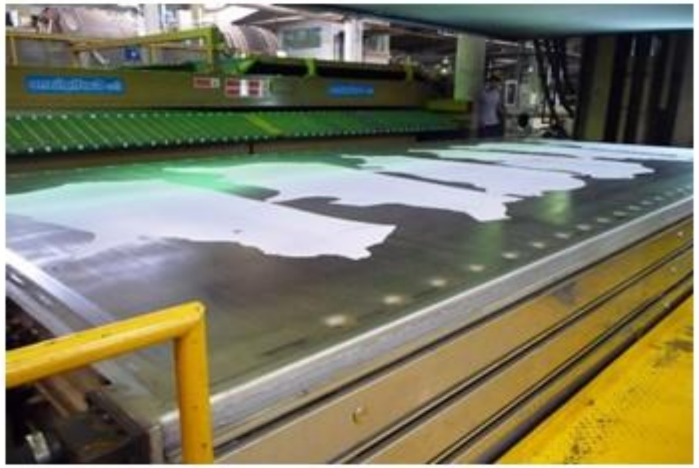


Multi-plate vacuum drying machine.

- **Leather is placed grain down on a heated and polished stainless steel plate. *(sometimes, sandblast plates are used to minimise minor grain defects).***
- **A hood is lowered on a timed cycle to form a seal with the heated plate.**
- **Air pressure is reduced within the enclosed volume via the hood by vacuum pump.**
- **This lowers the boiling point of water, causing fast evaporation.**
- **Vacuum driers were introduced to the sector in the 1960s and operate as multi-plate systems.**

Hand setting onto vacuum drying plates.

Leathers after mechanical loading.



- Leathers are extended by hand *(hand setting)* to avoid creasing.
- Mechanical loading systems are used, but operatives are needed to avoid pleating and for the removal of the dried leather.
- Temperatures of 45C and higher are common, but machines can operate at lower air pressures and temperatures.
- This method produces leather with a smooth grain, and sets the shape and area.

Pressure from the hood onto the leather increases as the air pressure is reduced. However, extended heat and pressure can cause over compression of the grain layer and corium. This can result in a firm leather and a deterioration of the break characteristics, especially if the plate temperatures are higher than 45C.

A balance is required. Normally the leathers are part vacuum dried only, completing the drying by tension-free drying *(suspension drying)* at a relatively low temperature.

Here, the shape and area has been stabilised in the vacuum drying operation without developing excessive firming. The secondary slow evaporation under tension-free conditions to the required moisture content favours softness.

2] Suspension drying:

Tension-free: suspension/hang drying after part vacuum drying.

Leather suspended on horizontal poles fitted to a line conveyor.

- A tension-free slow drying used on its own will produce a very soft leather, with a tight break.
- It is a slow process and allows shrinkage. This results in area reductions, and a tendency to revert to a more rounded form.
- Horizontal pole conveyor systems are mainly used after vacuum drying.
- These systems mainly rely on warm air at a high level in the building.
- Temperatures can be raised within tunnels built around the conveyor if required.

Once used heavily within bovine manufacture, suspension drying was often managed in sealed drying cabinets with forced air circulation and control of temperature and relative humidity.

It is normally used as a horizontal pole conveyor system as previously described, where drying of the part-vacuum dried leather is completed slowly and free of compression.

3] Toggle drying:

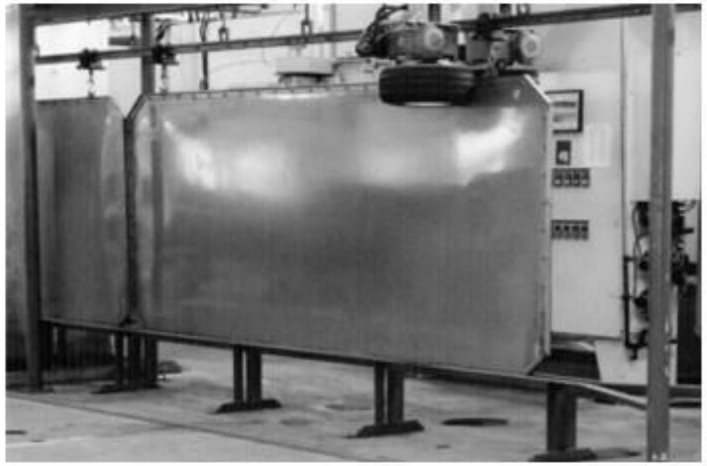
Toggle drying under high tension.

Removal of leather from split frame.

- **Leather is dried under tension by clipping *(toggling)* onto perforated frames.**
- **Frames are often made in two parts *(split frames)* to enable mechanical extension.**
- **This provides uniform strain and an increase in area.**
- **To ease loading/unloading, the frames can be pivoted to the horizontal.**
- **The drying takes place using forced air movement.**
- **The operation is managed by control of temperature and relative humidity.**
- **Makes a firmer and more extended leather than vacuum drying + suspension drying.**

Paste drying:

Vitreous plate awaiting paste spray.



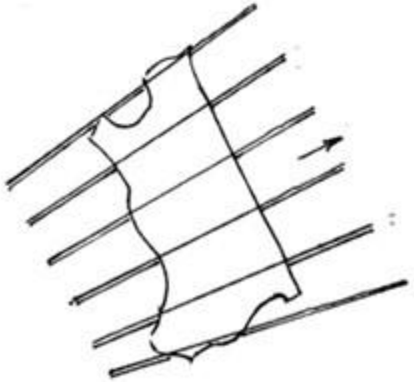
Hand slicking - leather grain to plate.

- This method is very effective, but now almost completely replaced by other methods.
- It is, however, of technical interest.
- Leather after samm/setting is stuck grain side to glass or vitreous enamelled plates using a starch based adhesive paste.
- After controlled cabinet drying, the leather is peeled from the plates.
- Paste is removed by either buffing or washing the grain layer.
- Produces a highly extended, flat grained leather, with reduced stretch.
- Evaporation from the flesh side only can result in surprisingly soft leather.
- This technique is used very occasionally for speciality leathers, and is effective for drying splits.

4] Dehumidification drying:

Manual presentation to dehumidification drying.

Off-set conveyor strings to maintain extension throughout drying operation.



- **Designed to follow wet stretching, leather is held horizontally and extended between pairs of feed-lines or strings.**
- **It is then dried using a series of air blades at moderate temperature as transported through the drying unit.**
- **The relative humidity *(RH)* is maintained by dehumidification.**
- **Moisture evaporates from the leather until there is an equilibrium between moisture retained in the leather and the designated RH.**

Out-feed from condition drying.

Auto-stacking under safe and secure conditions.

- The carefully controlled RH allows drying to a specific moisture content throughout the whole structure.
- The leather is therefore in a suitable condition for mechanical flexing and softening.
- The horizontal out-feed lends itself to conveyor linkage directly into the vibration staking operation.
- The cycle can be completed by automatic stacking.
- This high level of machine linkages creates a very fast drying cycle to the pre-finished state.

Review:

Drying operations are not simply the removal of water. As water evaporates from the leather, the fibre structure is brought together at both macro and molecular levels.

Strong and permanent adhesions occur that reconfigure the structure into a specified shape. This shape is determined both by forces applied in preparation for drying operations and during evaporation. This results in a flattened form and a general hardening of the structure.

The final orientation of the fibre structure, and the adhesions that develop are very significant in the determination of the physical properties of the leathers produced.

Within leather drying, evaporation takes place in two phases:

1st Phase:

Removal of physically held water – taken as complete when signs of dampness disappear across the surface of the leather.

2nd Phase:

Removal of chemically bound water – from the end of Phase 1 to the final moisture content. Strong inter-fibre adhesions develop within this phase.

In general:

The greater the fibre compression, both before or during drying, the firmer and more compact the leather.

The greater the extension *(strain)* applied and maintained in drying, the firmer and thinner the leather, the coarser the grain, and the greater the area obtained.

The higher the temperature in Phase 2 drying the firmer the leather.

More moderate conditions provide improved grain break characteristics.

POST DRYING OPERATIONS

The major physical properties and leather characteristics are determined by a combination of wet procedures and reconfigurations developed during water removal.

These properties can be amended to a degree in post drying mechanical operations.

The conditioning operation

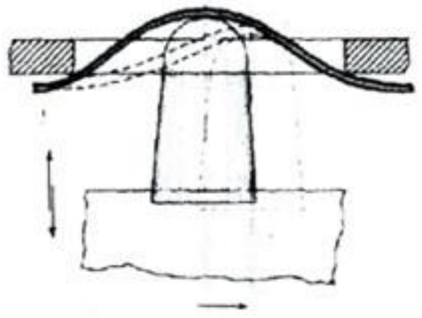
Leather conditioning by water spray.

Leather sealed to avoid moisture loss by evaporation.

- Often, after vacuum/suspension or toggle drying the leather is too dry.
- A light water spray - usually on conveyor - is used to dampen the leather.
- This is followed by stacking to develop an even moisture content throughout the leather structure.
- The leather is tightly sealed during this time to avoid edge drying.
- The leather is then in a suitable condition for staking.
- The conditioning operation can be avoided if dehumidification drying is used.

The vibration staking operation *(through-feed action)*

Combined vertical and horizontal action of staking/stretching pins.

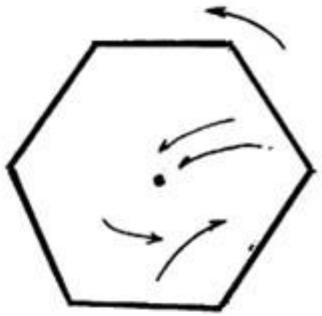


Feed to vibration staking operation.

- **Leather is transported through the staking action sandwiched between flexible conveyor belts.** ***(Machine design: similar to arrangements pages 3/9 and 3/10.)***
- **The frame mounted pins apply an articulated hammering action to the leather.**
- **Loosens weaker fibre adhesions.**
- **Softens and extends the structure.**
- **It is important to have the correct moisture content to avoid damage to the leather structure.**
- **This is followed by a short drying operation.**

Milling operation

The tumbling motion in milling.



Hexagonal, octagonal and circular milling drum designs.

- To create very soft leather, further mechanical action can be applied after staking.
- Known as milling, the leathers are tumbled in dedicated drums for long periods to soften and loosen the structure.
- The leather contracts, forming very defined pebbled grain texturing.
- These effects are dependent upon previous processing, temperature, and the moisture content of the air circulating within the drum *(RH control),* and mechanical action.
- There are many different drum shapes and internal peg and shelf arrangements.

Conditioning:

The vacuum drying/suspension and toggle operations aim towards a uniform moisture content. However, due to cross-hide variations, drying is often irregular, and leather is often dried to a lower moisture content as this provides uniformity.

These leathers are usually too dry for staking and are slightly dampened or conditioned, usually by a water spray. They are then stacked in piles and left to achieve moisture equilibrium throughout the batch. This operation usually increases the moisture content from perhaps 12/18% moisture to 22/28% *(according to requirements)* in preparation for mechanical softening.

Drying by dehumidification enables uniform drying throughout the whole structure. This is determined by RH control, and the conditioning stage is avoided.

Vibration staking:

First-time drying operations are part of a significant structural change. At the time of drying, the shape and physical properties of the leather are determined by controlled adhesions throughout the fibre structure.

However, some of the weaker adhesions can be loosened at this stage and allow some softening and general relaxation.

This is normally carried out using a vibration staking machine, where a strong flexing/stretching action is applied to the leather. This causes a relaxation to provide the softness needed in the final material.

In the staking operation the moisture in the leather helps avoid overstressing the fibre structure and maintains break characteristics. If the leather is too dry at this stage, then softening can only be achieved by overstressing the structure. In this situation ruptures can occur within the fibre matrix, creating a coarse break and a deterioration of grain appearance.

A slow drying follows staking - usually tension-free *(second time drying)* - to reduce the moisture content to 12-16% dependent upon end requirements.

Milling operations:

Further softening can be developed by milling, where dry leathers are drum tumbled. The conditions of temperature, RH and time are closely controlled in this operation.

Together with carefully developed earlier processing, both softening and required surface effects can be developed.

Various additives may be sprayed into the drum to develop tactile and handle effects.

Rationalisation:

Highly rationalised conveyor systems suit large scale operations. Horizontal conveyors can link samm/setting, wet staking/stretching and dehumidification drying to provide a leather with a moisture content suited for staking. Feed to a vibration staking machine *(multiple if needed)* can be added as well as automatic stacking.

Vacuum drying techniques with automatic loading can also be used instead of dehumidification drying, followed by drying free of tension.

There are many permutations within Stage 3 procedures, and processing times from the wet to pre-finished state can be reduced to one hour when operated as a production line system.

However, there are limitations dependent upon the range of leathers produced and scale of operation.

Small tanneries with a wide range of different leather types do not have the capacity for conveyor linkages and operate more effectively using batch operations.

Pre-finish assessment:

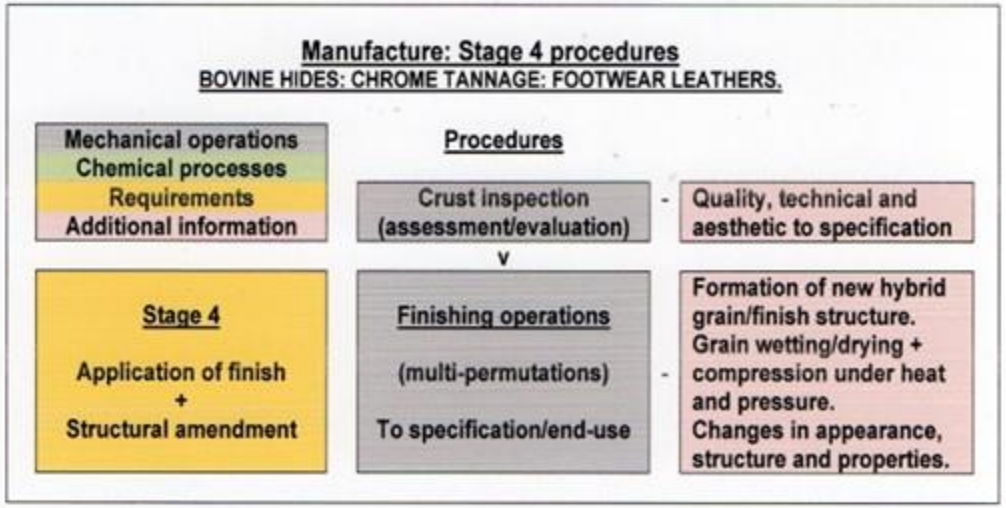
Leathers are normally inspected and graded after completion of the processes and operations described in Parts 1, 2 and 3 according to quality of grain, softness, colour, substance and suitability for customer specifications.

This is known as crust sorting, and ensures the leathers are in the optimum state before entering finishing operations.

- Free fibre movement is made possible in the first stage of leather making.
- In the second stage leather is made to suit customer needs.
- The final flat form is established in the third stage, with consolidation of the physical properties by managing the fibre adhesions.
- From a rounded and irregular waste from one industry, to a useful and valuable material to suit purpose.

Continues as:

"Overview" Part 4



- **Procedures set down in Stages 1, 2 and 3 provide leathers with properties to specification at the pre-finished state.**
- **Within finishing operations these leathers are tailored to suit both leather customer and end-user.**
- **The mix of physical and chemical properties developed within the leathers before finishing, and the finishes applied, need to work in synergy to achieve best results.**

(Version: 2024)

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 4)

Application of the finish

Authors: Paul Evans and Richard P. Daniels

Recommended by:

INTERNATIONAL UNION OF LEATHER TECHNOLOGISTS AND CHEMISTS SOCIETIES

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

This section includes a summary of hides and skins as raw materials.

Part 1: The removal of unwanted materials and extension of the structure.

Part 2: The introduction of new materials and extension of the structure.

Part 3: The removal of water and reconfiguration to a flat form.

Part 4: Application of the finish.

Part 5: Different types of bovine leathers.

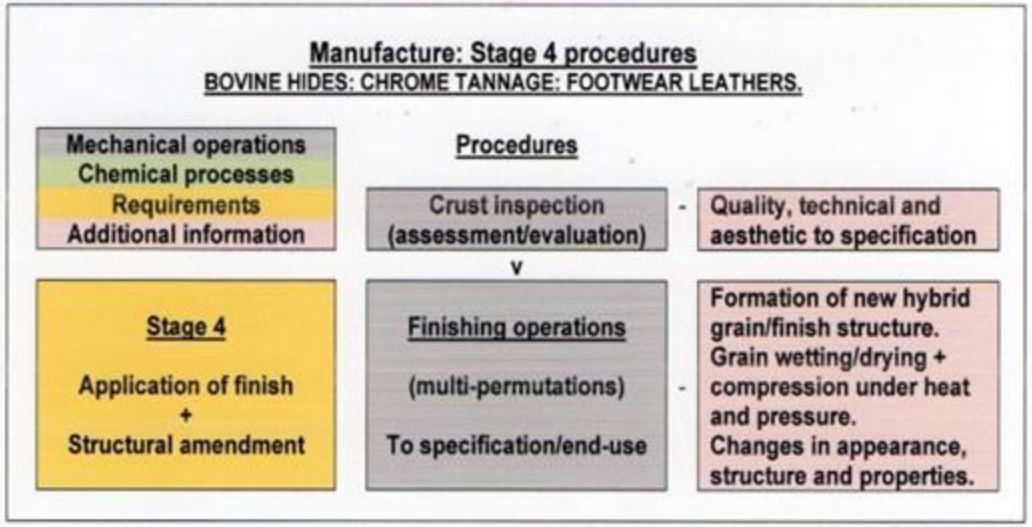
Part 6: Small skins: hair sheep and goat: grain leathers.

Part 7: Small skins: wool bearing sheep: double face, shearling and rugs.

Part 8: Discussion.

Annex.

Stage 4 procedures



- **Procedures set down in Stages 1, 2 and 3 provide leathers with properties to specification at the pre-finished state.**
- **Within finishing operations, these leathers are tailored to suit both leather customer and end-user.**
- **The mix of physical and chemical properties developed within the leathers before finishing, and the finishes applied, need to work in synergy to achieve best results.**

FINISHING PROCEDURES

Surface coatings are developed on the grain surface for protection, precise colour, and visual enhancement.

Within these operations, the final leather appearance and aesthetic characteristics are developed.

This involves the application of liquid finishes - binders, colour to specification and various auxiliary products - and the development of protective films.

Many different effects are possible to meet fashion and end-user demands.

Finishes are mainly developed using precision machines.

Both heat and pressure are required to complete these operations.

These operations also influence the final physical properties of the leather.

This can involve:

Chemical coating applications:

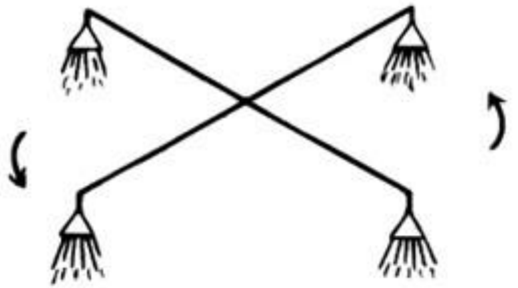
- **Spray machine.**
- **Roller coating machines.**
- **Sometimes by hand.**

Physical (machine) operations:

- **Drying, cooling and conditioning.**
- **Smoothing/embossing and consolidation - roller/ram pressing.**
- **Texture and handle – milling and staking.**

Spray operations

Movement of the spray gun assembly.



Spray finishing in sealed cabinets.

- Very light finishing may use spray applications alone.
- The spraying assembly comprises either 4, 8,12 or 16 spray guns carried on rotating arms, or 2 or 4 guns on a single arm.
- The leather is generally fed into an enclosed spray cabinet supported on a stringed feed conveyor.
- Several applications can be used to provide sufficient cover of the grain surface to a precise shade and thickness.

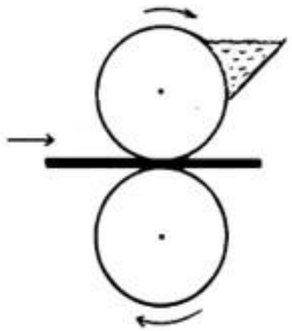
Careful presentation of leather.

Area scanned to avoid over-spray.

- Area scanning under micro-processor control ensures that spraying only occurs when leather is positioned under the spray area.
- This minimises overspray and waste.
- The feed systems and machine controls can ensure reproducibility of a given process.

Roller coat operations

The reverse roller coater action.



Presentation to the support roller.

- Roller coating operates on the principle of transferring the wet finish from a stainless steel engraved roller onto the leather surface.
- The leather is presented to the support roller by a feed-belt or table.
- The transfer of finish is precisely determined by the depth of engraving, the setting of a doctor blade and direction of rotation of the application *(top)* roller.

Through-feed of wet coated leather.

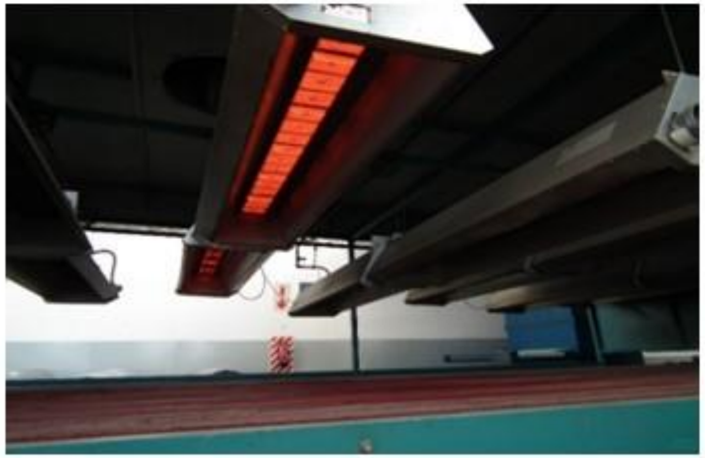
Grain patterning using special rollers.

- Once the wet application has dried a film is created on the leather surface.
- There may be several of these applications, with intermediate drying, with spray coats often applied as final top coats.
- Special surface effects such as shading, tipping and clouding can be developed by forward roll coating.

Drying operations

Spray cabinet coupled with drying unit.

Radiant heat - both electric and gas.



- After wet finish applications, the leathers are conveyed by machine linkages into drying units.
- The finish is dried using forced air circulation at controlled temperatures within these cabinets.
- Steam radiators are used for air heating, but direct radiant drying is also employed.

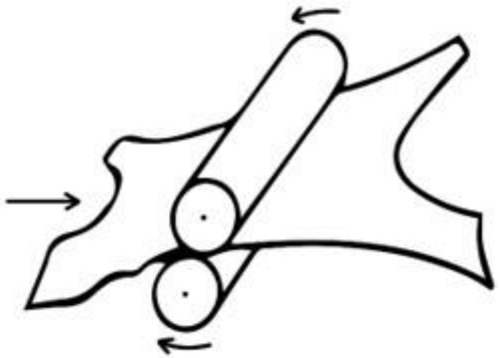
Water removal in drying cabinets: essential part of film formation.

Finish films created to specification.

- Polyurethane, acrylic and butadiene polymer binders are used within finish blends to provide different physical properties to the finished leather.
- On water removal in drying, these selected polymers coalesce to create a continuous and protective film.
- These are important steps in developing the properties of a finish to meet different end needs.

Roller press or ironing

Roll press action.



Presentation to the roller press.

- Hot roll pressing or ironing may be used for these operations.
- The finish film - being thermoplastic - softens and flows forming a smooth flat surface on the grain of the leather.
- Through-feed rolling systems are mainly used.

Example of a highly polished roller.

The support cage rotates for fast exchange of pre-heated rollers.

- The rollers may be smooth and polished, or have textures engraved into the surface.
- Different rollers create detailed grain effects.
- Several rollers may be carried on a single machine.
- Before use they can be pre-heated as required to enable a rapid change of rollers.

Ram or platen press

The ram press action.

Considerable pressure is possible.

- Platen pressing employs a heated plate fitted in a ram press as an alternative technique to roll pressing.
- Smooth and engraved plates are interchangeable, and a huge range of patterns can be printed or embossed into the leather grain.
- This is a versatile operation, and very high pressures can be employed.
- Often used for smaller volume production.

Other considerations:

Production runs may be large or small, and customer needs are subject to fast change.

The layout of the finishing plant and its management by necessity is highly flexible.

There are many different combinations of finish applications and operations.

Some insight into these issues and the technology involved follow.

Finishing by hand

Both heavy and delicate applications are possible by hand finishing.

Considerable care is required for uniformity of covering and colour.

- **Small volume speciality batches and samples are often finished individually.**
- **Heavier coatings may be applied by hand using application pads.**
- **These can be followed by hand spray finishing.**
- **Very light finishes may be developed by spraying alone.**

Linkages and rationalisation

Roller coater and conveyor – rail mounted.

Auto-stack at end of spray units.

- Roller coating, spraying and tunnel drying are through-feed systems.
- These suit rationalisation for normal volume manufacture.
- Machines mounted on rails may be introduced into production lines as required.
- Units can also be linked by movable conveyors.
- Leathers may be handled at take-off by stacking devices.

Milling and vibration staking

Milling drums - used within finishing.

Vibration staking – and too.

- In addition to applications after 1st time drying, both milling and vibration staking operations *(also stretching machinery)*, can be used within finishing.
- Milling is used for tumbling soft leathers for further softening.
- It is also a means to enhance some grain effects.
- Vibration staking is employed too for relaxation and flattening after milling, and lighter softening needs.

Bovine full grain tumbled with water repellent spray finish only.

- Various grain effects can be developed by milling within finishing.
- The grain enhancement is dependent upon the mechanical action, time, temperature and RH required in tumbling.
- However, the most subtle grain appearance and surface texture relies on the finishing techniques.

Review:

Finishing operations are the final stage in creating the final leather appearance and properties.

This involves the application of liquid finishes - binders, colour to specification and various auxiliary products - to the grain layer and the development of protective films.

Both heat and pressure are required in these operations, to complete the final physical properties of the leather.

The operations can be highly mechanised, but small lots employ hand operations and specialised techniques.

Flexibility is required to meet fast changing customer demands.

FINISHING REQUIREMENTS

There are many different finish requirements in terms of colour, texture and tactile effects.

The amount of cover and visual effects required are considerable, and subject to changing customer and fashion demands.

The products available are sophisticated and provide different physical properties.

The physical properties of the pre-finished leather are amended within finishing operations.

Variations within finishing

There are six major variations within finishing.

These comprise of two different grain structures, and three different categories of finish, as set down in *Panel 2:*

.

Panel 2			*"Overview" ©P. Evans*
	Finish variations		
Structure	**Category**		
Full grain	Aniline	Semi-aniline	Pigmented
Corrected Grain	Aniline	Semi-aniline	Pigmented

Full grain leathers

The natural beauty of full grain leathers.

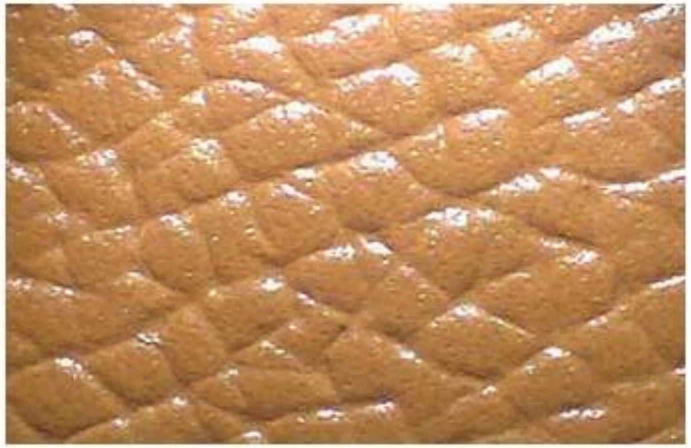
- Where the leather surface is good quality, the finish may be applied directly to the grain layer.
- These leathers are known as full grain leathers.
- They are often finished by a light spray application.
- It is important that the grain characteristics remain visible and are enhanced.

Full grain leather: unfinished

Full grain leather: light aniline finish.

- Aniline finishing develops and enhances the beauty of the natural grain surface.
- The finish also provides protection and maintains appearance during use.

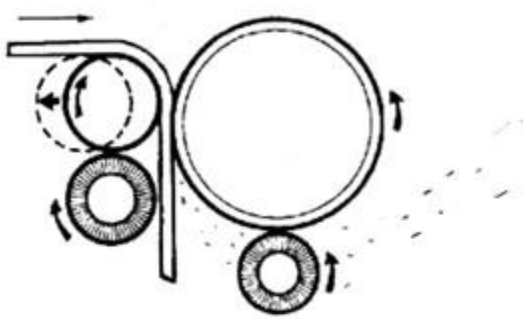
Full grain leather: pigmented finish.



- Pigmented finishes can be used to cover fine surface defects.
- In this example the leather has also been embossed.

Corrected grain leathers

Action of the buffing machine.



Corrected grain leather after buffing and de-dusting.

- Leathers with small surface defects may be buffed.
- This operation is carried out by feeding the grain to a rotating cylinder covered with emery/sand paper.
- This removes small grain irregularities and forms a more uniform surface.
- Dust created is removed from the grain by air blast.
- These are known as corrected grain leather.

After buffing, a new grain surface needs to be made.

Requires application of an emulsion of soft acrylic resin to the buffed surface.

Known as impregnation, these resins fill and support the new surface as a secure base for further finishing.

After drying + light re-buffing, this uniform surface enables heavy finish applications.

Applications mainly by roller coaters - occasionally spray or curtain coating equipment.

Categories of different finishes

Aniline finishes:

Some leathers have simple finishing techniques. They rely heavily on accuracy of dyeing and specialised properties developed in pre-finishing procedures.

Aniline finishes consist of a transparent film containing dyestuffs to adjust the shade to pattern. Here, the grain detail must be clear through the finish to retain the natural grain appearance. Pigments cannot be used in these finishes.

Semi-aniline finishes:

Some leathers are not entirely suited for aniline finishes, although they can be of high quality. In this instance, a small quantity of pigments of ultra-fine particle size are added to the finish formulation. These partially cover or mask minor blemishes and leave the skin with a natural appearance.

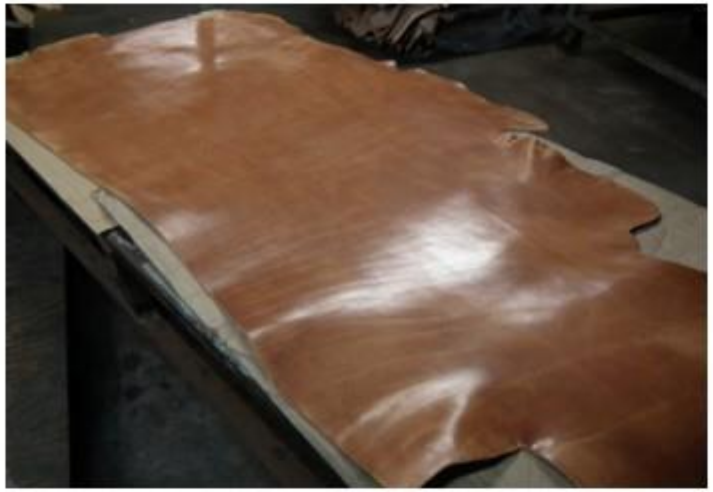
Pigmented finishes:

These finishes are used for leathers with a lower quality grain surface and corrected grain leathers. The film formed mainly consists of pigments and binders to provide good cover. These finishes can provide a high level of protection.

Within these six variations there are speciality leathers.

Waxy and Oiled effects:

Both high gloss and matt appearances.



- **Development of handle and finish characteristic begins at time of dyeing and retannage.**
- **Finishing is based on blends of oils, waxes or greases to give a specified feel and appearance to the leather.**

Nubuck leathers:

Fine buffed grain for nubuck leathers.

- Buffed lightly *(snuffed)* on the grain.
- These leathers do not have any finish applied.
- The end appearance and uniformity is dependent upon the quality of dyeing and buffing.
- There may be a light spray with special dye solutions to match a colour pattern and treatment with water repellent agents.

Suede leathers:

Uniform colour and surface fibre length *(nap)* for quality suede.

- **Buffed heavily on the flesh side and unprotected by finish applications.**
- **The end appearance and uniformity is governed by uniformity of dyeing and the buffing operations.**
- **The surface fibre length is a key feature of these leathers.**
- **There may be treatment with water repellent agents.**

Flesh splits:

Suede split with two-way rub effect.

Splits have many uses:

- They can be heavily buffed to create a smooth and uniform surface before finishing.
- They can then be heavy plated for fibre compression and surface consolidation before finishing.
- Alternatively, they may have been previously processed for suede leather.
- The retannage and buffing techniques determine the fibre length and surface effects including “two-way rub”.

Review:

There are many different types of finishing.

Applications can be minimal, or provide heavy cover and protection.

In general, after suitable preparation, water-based finishes are applied to the grain by roller coater or spraying machine.

The first application penetrates the grain layer, the binders selected being relatively soft for good adhesion.

Once dried, this hybrid grain/binder structure carries the subsequent finish applications.

There are usually several subsequent applications of finish.

Each application may carry progressively harder properties so that the top coat provides good wear resistance.

The amount of cover and visual effects required are considerable and fast changing.

The products available are sophisticated and provide different physical properties.

Plating under conditions of heat and pressure may occur between finish coats. The plates/cylinders used may be smooth or embossed, so that patterns can be created within the leather for numerous effects and grain textures.

This is generally followed by spraying a top finish to improve wear resistance.

Specialised top sprays of waxes or silicones may be used to enhance the feel, handle or tactile characteristics of the grain surface.

Most finishing blends and techniques employed are complex and developed to suit precise marketing requirements.

The finish must be able to stretch with the leather and be compatible with the demands of the client in further manufacture, and in end consumer use.

The properties of the final finish have to meet precise specifications in terms of colour and brightness of finish, aesthetic characteristics and physical properties.

Each end use carries its own demands. Official standards and limits are defined, but many customers set their own specifications.

These are based on properties expected when using leather in the production of an item, but clients often have additional needs. In addition, customer expectations change as do wider marketing demands.

Leather is increasingly being used in multi-fabric construction too. Over and above materials compatibility, colour-fastness and non-migration of plasticisers and oils are needed when combined with other fabrics.

Finishing requirements are subject to rapid change.

It should also be taken into account that specific properties have been developed in the crust leathers.

In finishing, water within the finish causes a wetting of the grain surface and causes grain swelling.

Heat is subsequently used to remove water from the wet finish application and the grain layer.

Further, heat and pressure is used to both flatten the grain surface and to soften and smooth the finish film.

But these operations cause fibre compression.

This causes a firming of the leather and changes both aesthetic and physical properties.

Flexibility and grain strength will change, as well as general softness and tensile strength, and even water resistance.

- Major leather properties are defined at the pre-finished state.
- These are modified within finishing operations.
- Finishing provides beauty and protection to leather at the end of leather making.
- Technology has to address these sometimes conflicting values.
- This is the art of finishing in leather making.

Continues as:

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 5)

Different types of bovine leather

Author: Richard P. Daniels

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Part 8: Discussion.

Annex.

Parts 1, 2, 3, and 4 sets down the general procedures for manufacturing chrome tanned shoe upper leathers.

The broad details apply when making other bovine leather types, but with changes in technique according to the hide/skin characteristics and end requirements.

Various options are given in the following sections:

Automotive and upholstery: comparison with footwear leathers

The differences between the manufacture of automotive and upholstery leathers, when compared to shoe upper leathers, have been largely shaped by the need for cutting large components for panels for seating constructions.

Also, longer life-use and durability, as opposed to serving the requirements of shoe upper leathers which are often fashion driven.

In addition, auto and furniture leathers are mainly lower in substance than shoe upper leathers, and this favours the processing of cow hides.

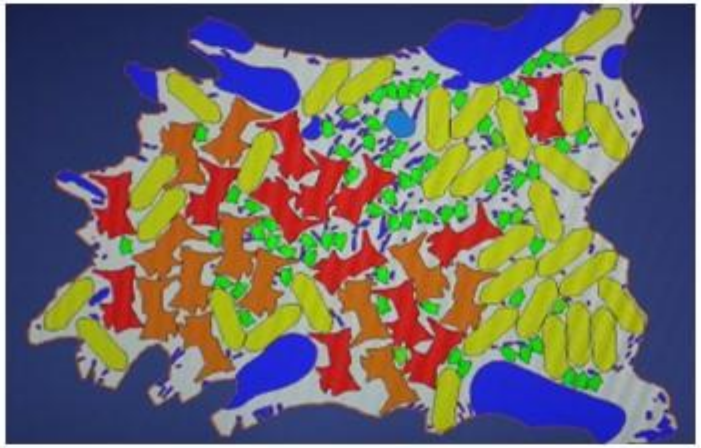
For the same raw hide weight, cow hides provide a greater area of lower substance than bull hides.

Defects identified before cutting automotive leathers.

Templates positioned around defects before press cutting.

- For automotive interior use, there is a need for larger components in the construction of seating and panels.
- Areas free from defects are required in the most visible parts of the seat.
- Faults in the grain surface are revealed by stretching the leather, then marked to identify.
- Patterns are then positioned around these defects before press cutting.
- Alternatively, cutting may be computer managed.

Computer cutting option based on hide defects + directional stability.



Steering wheel components - high compatibility essential in assembly.

- Dimensional stability is a particularly important property too.
- The components required for seating, steering wheels and trim must retain their shape and integrity in assembly and long term wear.
- This is a key consideration when cutting requirements are determined.

Required: long-life and durability for high wear/exposed auto interiors.

Aggressive situations: saddles and customised fuel tank covers.

- Whole hide processing for both automotive and furniture leather manufacture is needed to obtain the best cutting coefficients and minimise waste.
- In comparison, the components required in footwear construction are relatively small.
- The various patterns can thus be more tightly positioned.
- Sides can be managed easily and cut efficiently when cutting *(clicking)* components within footwear manufacture.

For automotive manufacture:

Larger scale machinery is needed from the tanned to finished state to handle hides.

These are expensive, large capacity machines, and this favours high volume production.

Production runs for auto-supply are large and predictable in terms of substance, surface pattern, colour, handle and physical properties.

This means that considerable rationalisation is possible.

This favours fewer but larger capacity units.

In comparison, the footwear leather manufacture:

Has a wider spread of customers, but mostly as smaller size units.

The range of substances, surface patterns and effects, colour, handle and physical properties required in footwear construction is considerable.

Accordingly, production batches tend to be smaller.

Leather requirements and specifications are also subject to considerable change.

Rationalisation is possible in hide production until the tanned state.

Rationalisation from the tanned to finished state is more limited due to the bespoke needs of customers.

Linkage between samm/set, wet stretch, drying, staking & stacking.

Conveyors can link pairs of spray cabinets/drying tunnels/stackers.

- For auto leather manufacture, rationalisation offers a shift from batch to line production.
- Machines can be brought together and linked by conveyors.
- Individual hides can be processed from the wet dyed state to pre-crust condition in as little as one hour.
- Many linkages and high through-put is possible in finishing too.
- This minimises variation, the quantity of goods in work, and reduces labour costs.
- This provides technical and production advantage.

Tannages for auto and furniture leathers

Chrome tanned leathers:

For chrome tannage of limed split bovine hides, there is very little difference in chemical processing when compared to footwear leather manufacture.

And, over and above issues of rationalisation, the machine actions are very similar.

The chemical and physical requirement for auto and furniture leathers need emphasis in areas of lightfastness, abrasion resistance, perspiration, odour/emissions, changes associated with ageing, and needs of long-term use.

However, at the same substance and softness, in the broadest terms, the manufacturing approach for footwear, auto and furniture uses are similar.

White tannages:

For the various “white” tannages the mechanical operations required in making auto / furniture leathers are interchangeable with chrome leather manufacture.

However, higher offers of retanning agents and fatliquors are needed to achieve similar handling and aesthetic characteristics when compared to chrome tannage. This is because of the different properties in terms of tightness, dimensional stability, and emptiness within the “wet-white” structure.

Moreover, chrome tanned leathers carry a strong cationic charge that enables greater fixation of anionic products and less waste.

There are technical differences between the chrome tanned and “white” leathers in terms of performance.

Leather for furniture use

Heavy duty + easy clean seating as fitted in this rail carriage interior.

Luxury home fittings providing good design and comfort.

- Automotive interiors may be robust and utilitarian, or customised and refined to meet a precise customer specification.
- There are other uses for these leather types too - for example - aircraft and rail carriage seating and power boat fittings.
- Where use is high - commercial aircraft, bus and train interiors - easy clean properties are necessary for good hygiene.
- Similarly, furniture leathers have to meet a wide range of needs and specifications.
- Includes durability, comfort, odour-free and fire retardant properties.

Leather for clothing

Made to measure – value adding for a small skin manufacturer.

Bovine clothing leathers for jackets and full length coats too.

- Clothing leathers are mainly made from sheep and goat skins.
- Bovine clothing leathers are not so common, but in this event, are usually made from cow hides.
- These have a relatively high grain to corium thickness ratio.
- This provides less resistance to tearing at low substances.
- However, these leathers can be very soft, generally with a more open break than provided by smaller skins.

Bags and leather goods

Dyed belly leathers, air-dried free of tension, awaiting tumbling.

Bags from a variety of bovine and small skin leathers.

- There are many different types and uses for bags and leather goods – both high fashion and general accessories.
- Specialised manufacture required for high value products.
- However, leathers often adapted from other types of production.
- Includes chrome, wet-white and light vegetable tannages.
- The residual belly and shank parts from "squaring" raw hides are ideal for super soft bag making.

Miscellaneous vegetable tanned bovine leathers

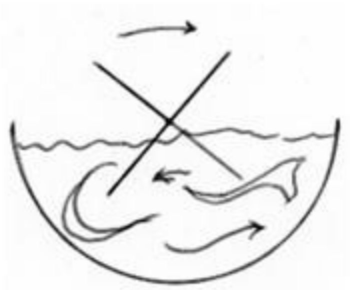
Details concerning heavy and light vegetable tannage have been given in Part 2. However, there are significant differences in manufacturing techniques compared to other bovine leather manufacture.

Heavy vegetable tanned leather making is determined by four main factors:

1) The need to achieve the highest usable substance at selection after tannage.
2) The high quantity of vegetable tanning agent required for tannage and to provide filling within the structure.
3) The length of time of the tanning technique when compared to other systems.
4) The tendency for vegetable tanning to discolour due to migration of tannins in drying operations.

Heavy vegetable tanned leathers

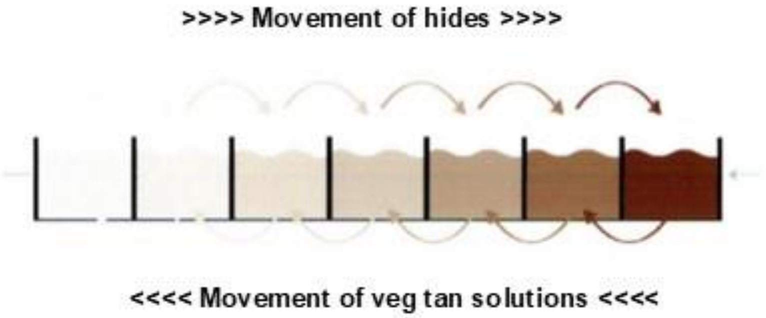
Paddles: rotating paddle blades keep hides and float in motion.



Paddles are often fully covered to prevent heat loss.

- Large hides are mainly used as they provide the greatest substance.
- Limed splitting is usually avoided to retain the greatest hide thickness selections after tanning.
- Hides are sometimes "white limed" *(suspension in lime solution only)* after fleshing as an extension of liming.
- Drums are used for liming and deliming, but some use of paddles.
- Otherwise, the processing is similar to other bovine leathers until the tanning stage.

Counter flow movement of hides and veg tan solutions.



Hides are suspended on frames, and moved using overhead hoists.

- Pit tannages are used, with an absence of mechanical action.
- Tannage commences with hides being introduced to weak exhausted tanning solutions.
- They are gradually moved to pits of higher tannin concentration.
- As tannins are taken up by the hides, the concentration reduces.
- These solutions of lowering concentration are moved in counter flow to the hides.
- This can take +/- 10 days.
- Drum systems can be used, but the uptake of vegetable tanning agent is less than with pit systems.

(Ref: Part 3: 15 - 22)

On selections, higher substances have the higher potential value.

Hot greased leathers, after setting on flesh side, in 5-day “laying” time.

- Many different mechanical operations when compared to other bovine leather types.
- Splitting in the tanned state is needed after selection to gain the greatest substance from these leathers.
- Retannage is minimal as the structure is already highly filled with tannins.
- Fatliquors or greases are applied for surface lubrication, dependent upon end use.
- Softening operations such as vibration staking and milling are not employed.

Slow toggle drying may be used.

Tension-free drying too - as with these *(squared)* hide butt sections.

- The drying times are very slow and carefully controlled.
- This is because vegetable tanning agents are not fixed as strongly to the collagen as chrome tannages.
- As water evaporates from the surface, veg tans can migrate within the structure.
- This causes both surface discolourations, and a build up of veg tans within the grain layer.
- This excess of tannins causes a weakening of the grain structure too.

High pressure rolling for soling to consolidate the structure.

Glazing to develop a high gloss wax aniline finish.

- Finishing is comparatively basic compared to footwear and upholstery leathers.
- The leathers are often rolled under high pressure to consolidate the structure.
- Usually, the leather has only a very light protective cover.
- This can include applications of wax or oils, hot rolling for fibre compression, and high gloss effects.

Light vegetable tanned leathers

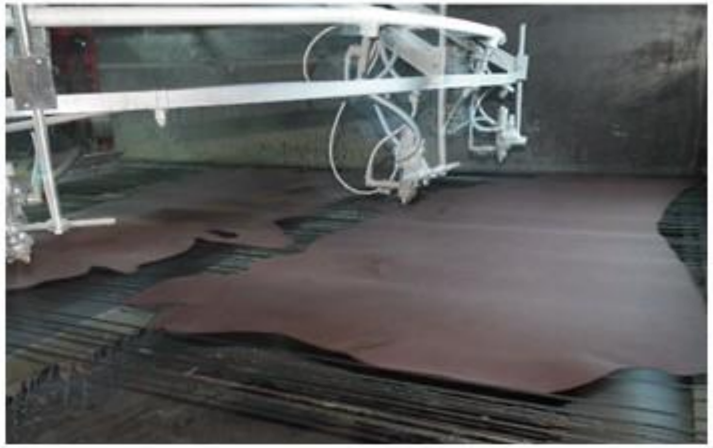
Drum processes are used for liming, deliming/bating, pickle and tannage.

Tanning agents are mainly lighter in colour than used for heavy leather.

- The requirements for “light leathers” differ from heavy vegetable tanned leathers.
- The quantity of vegetable tanning agent required for tannage is less than required for heavy leathers.
- The tannage is performed in drums and is relatively rapid.
- These leathers may be retanned fairly heavily to modify the leather for different uses.
- The processing details - apart from tannage and avoiding high temperatures in drying - can be more similar to footwear leather manufacture.

(Ref: Part 2)

Conventional softening, buffing and finishing procedures, as required.



Bespoke luggage from tumbled vegetable tanned bovine leathers.

- Wide variety of end uses - shoe upper leathers, bags, wallets, general leather goods, and occasionally upholstery.
- Size of cut components can vary, but mainly smaller items.
- Appearance “improves” on ageing and use.
- When used for both shoe uppers and linings they offers both comfort and hygiene.
- Antibacterial properties provided by the tannins, and high moisture vapour permeability for coolness.

Suede leathers

There are several different suede leather categories.

Traditional suede leathers are based on a raised open fibre structure *(or nap)* on the flesh side of upper leathers, created by heavy buffing.

Velour or nubuck leathers are also produced as upper leathers, where the grain layer is finely buffed, creating a high value product.

Most suedes, however, are based on processing flesh splits as follows.

Trimming flesh splits after limed splitting.

Careful selection for substance potential before blue splitting.

Splits are produced from two different parts of manufacture:

1] After limed splitting:

- **Limed splits are sold for food processing, or bio-gas production.**
- **However, they may be trimmed, and receive a tannage as splits.**

2] After tannage:

- **If splitting takes place after tanning, these splits tend to be thin as pre-splitting gradings focus on seeking the highest substance of the grain split.**
- **Splits are mostly from chrome tannage, but some arise from vegetable tannage too.**

Undyed splits

Vacuum drying commonly used for split drying.

Finishing undyed splits for light sports footwear trimmings.

- After shaving, splits may be lightly retanned and fatliquored, but without dyestuff additions.
- After drying, these splits are buffed.
- They may be heavily finished, or laminated for applications.
- Many variations.
- Uses include linings for footwear, some types of shoe upper, belts, trimmings, seating panels, and leather goods.

Dyed suede splits

Setting to avoid compression and firming, before a tension-free drying.

Splits after buffing, de-dusting and milling.

There are two methods of processing splits as dyed suede:

1] Direct dyeing:

- The leather is dyed to shade at the time of retanning and fatliquoring.
- They are dried, then heavily buffed to produce a suede with fibre length as required, then de-dusted.
- They are softened by milling or tumbling.
- The milling action also raises the surface fibres or “nap”.

Buffing is critical as there is high variation in flesh fibre length.

Suede after silicon spray to enhance water repellency.

2] Crusting and dyeing.

- The splits are retanned and fatliquored without dyeing.
- After drying, they are buffed to produce the required nap.
- They are then inspected for quality, and if necessary rebuffed.
- They are then dyed to shade and redried.
- There is no further buffing and no residual dust.
- This produces a uniform nap, with very consistent dyeings.

Nubuck leathers

Nubuck leather after second time drying for inspection and trim.

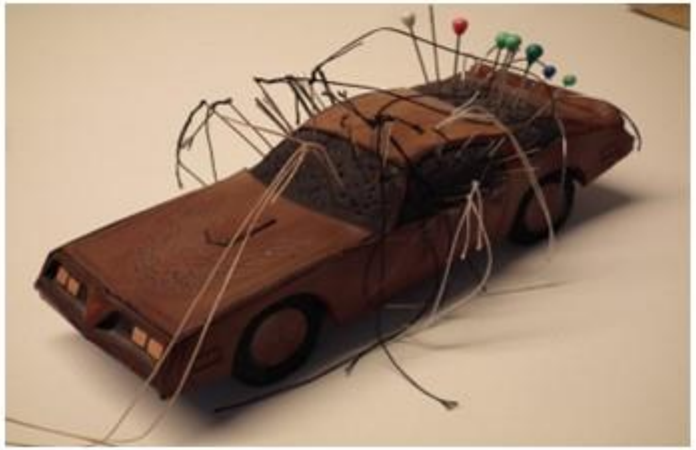
Nubuck leather awaiting final dispatch.

- These are pure aniline leathers, that have been buffed on the grain side to produce a very fine and uniform "velour" grain surface.
- As there is no "cover" in finishing, the grain should be free of small surface detects.
- For the highest quality, they are manufactured to the crust state, buffed, inspected and re-buffed as necessary.
- They are then dyed to shade in a similar manner to high quality suede, and redried.
- Without any cover in finishing, the only protection is by a final water repellent spray.

Uses for trimmings

Leather gear shift covers being carefully hand stitched.

Pin cushion created from vegetable tanned cuttings.



- There is little waste after cutting components.
- Dependant upon the leather type, uses range from small items such as key fobs, to mobile phone cases and auto gear shifts.
- There are examples of suede cuttings as small as 3 x 3 cm being stitched together, then cut and used for bags.

Review:

The various bovine leather types follow the four stages of manufacture as described in previous Parts.

The equipment used is similar, but of different size and detail according to side or whole hide manufacture, and end specifications.

Large volume runs of production significantly influence the degree of rationalisation that is possible.

In turn, this affects the uniformity and logistics of manufacture.

Probably the greatest differences in manufacturing technique are found with heavy vegetable tanned leathers.

This is due to weight of individual pieces, the lack of mechanical action in tanning, the properties of vegetable tanning agents, and the need for a firm compact structure.

Continues as:

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 6)

Small skins: hair sheep and goat: grain leathers.

Author: Richard P. Daniels

Recommended by:

INTERNATIONAL UNION OF LEATHER TECHNOLOGISTS AND CHEMISTS SOCIETIES

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Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

This section includes a summary of hides and skins as raw materials.

Small skins: hair sheep and goat skin leathers

There are logistical and technological differences when compared to bovine leather manufacture.

There are four prime matters to take into account:

1] Structural differences.

2] Skin collection and preservation.

3] Availability and supply.

4] Grading and selection.

1] Structural differences

Micrographs have illustrated both the structural and thickness differences of bovine, goat and sheep skin leathers *(Content and Structure: pages 14, 15 and 16).*

Globally, the average weight of bovine hides is set down as 26 Kg *(variations between 8 and 35+ Kg according to region)* with sheep and goat skins 1.5 Kg *(with variations).*

In addition, a sheep or goat skin may be 5 to 10 times smaller in area than a hide. To achieve the same production in terms of area, many more small skins require processing than bovine hides. This means more handling.

The substance is also less. Skins can be extended or strained more easily than hides, and full penetration of chemicals throughout the structure is much faster.

These differences are addressed by machinery of different size and function, and variations in chemical processing too.

2] Skin collection and preservation

The husbandry of bovine cattle is mostly ranch or farm orientated, with a relatively small volume as subsistence animals. These animals are managed for dairy and meat production: slaughter and preservation can be considered centralised.

Sources for hair sheep and goat are largely Africa, the Middle/Far East, and Asia, with a high percentage of subsistence animals. Flocks are numerous, and relatively small in size.

Similarly, slaughter is mainly on a smaller scale and decentralised.

Skin preservation is local, with collection of skins, preservation and trading often through long established trading links: small scale collection feeding larger scale dealers.

Inevitably, this leads to variations in both skin size and quality due to wide ranging environmental and husbandry matters, slaughter practices and quality of preservation.

3] Availability and supply.

Hair sheep and goat are a food source subject to significant variations in demand. At times of fasting there is a very low availability of skins. But, at times of feasting and festivals there is considerable over supply. This is often coupled with poor preservation practice with subsequent skin damage.

For a tannery, these variations mean that large stocks of skins are required to level and manage production.

Preserved raw skins can be kept in store for moderate lengths of time. However, skins are often processed directly by tanners to the pickled state where they can be graded and kept for long periods.

It is also common practice for skins to be processed at collection points by small enterprises to the pickled condition, even to the tanned state. For small skins, this does not require a high investment in sophisticated plant and machinery.

4] Grading and selection

Inconsistencies in the state of preservation, quality, size and substance, are major factors to address in the purchases of small skins. Potential is far from clear in the raw state, only becoming better defined as the goods are processed.

A large part of skin availability and supply is in the pickled state and from many sources. This has major scope for technical variation, more so to purchases in the tanned state.

The thickness of these skins does not lend itself to splitting in the limed or tanned state. Accordingly, there is no usable flesh split to add value to, and the final substance is mostly dependent upon shaving only.

If the potential thickness is not managed correctly at various sorting stages, there can be serious waste of substrate and chemicals in the form of shavings.

Over and above issues of quality and area, the greatest potential of each skin needs extracting in terms of quality and thickness.

If the focus is entirely on one type of leather, there will be many skins that do not fall within the thickness/substance requirements. It is therefore usual for tanners to make a range of quite different types of leathers: larger skins for various footwear uses and clothing leathers, with gloving and golf leathers for smaller skins at lower substance.

The early stages of processing are reasonably generic, and the pickled stage provides a stable structure that enables good grain assessment. Accordingly, this is the key point for inspection before commitment to a specific end use.

Manufacture: raw to the pickled condition

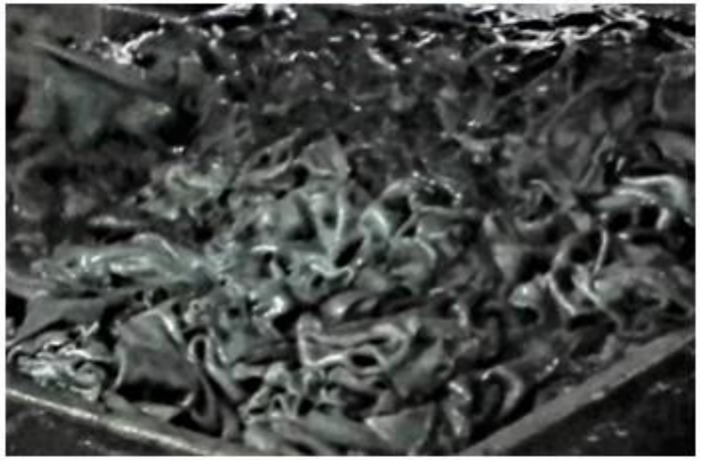
Sorting wet salted hair sheep skins.

Trimming and grading hair sheep.

- Skins are first sorted for general quality and state of preservation.
- They are then inspected for flay cuts - as this affects potential substance - then trimmed and graded.
- For example, there may be 4 different selections for area, and 4 grades for quality in each area selection.
- The skins may also be graded for colour of hair *(black, white, brown)* as any residual pigmentation in the grain will affect dyeing potential.
- As each batch is complete, it can be held in stock until required for soaking.

The hair burn process:

Hair sheep skins after a hair burn drum liming.



Limed fleshing hair sheep.

- Soaking is mainly performed in drums.
- If the hair has no value, this is removed by dissolution or “hair burn” as within a conventional unhairing/liming system.
- After washing, the skins are limed fleshed.

The hair save process:

Brush application of unhairing "paint."

Skins piled to enable "paint" penetration to the hair root.

- Soaking is mainly performed in drums with a high float, but also in paddles.
- The skins are stacked and drained.
- Hair saving is practised where the hair has value, or to reduce the load on wastewater treatment.
- The hair is released by breaking down the hair root using a "paint" based on lime and sodium sulfide.
- This "paint" is applied by brush or machine spray to the flesh side.
- Skins are piled, *(in pairs, flesh to flesh)* with penetration of the "paint" through the skin structure to the hair root in 1-3 hours.

Manual removal of hair by "pushing".

Cylinder and blade arrangements in an unhairing machine.

- Once the hair root is destroyed, the hair can be easily removed.
- This is mostly as a hand operation *(pushing)*, but can also be by machine.
- The configuration of the unhairing machine is similar to a fleshing machine, but with blunt blades to apply a setting or pushing action across the grain.
- The skins are then limed in a drum using slaked lime and a small amount of sodium sulfide - typically a 1-day unhair/liming cycle.
- They are then limed fleshed.

Recovered hair and skin pigmentation

Natural drying of recovered hair.

Compressed and baled hair.

- Sorting arrangements in the raw state can include hair colour.
- Selections can include black, brown, and white hair.
- The recovered hair may be washed, dried, baled and sold according to colour.
- This can be turned into traditional clothing and blankets without any use of dyestuffs.
- If there is residual pigmentation in the grain at pickle inspection, these skins can be dyed black.
- It is possible to bleach the pickled skins using permanganate or chlorine dioxide.

Options for pickling

It may be that production continues directly from a moderate acid/salt pickle into chrome tannage.

However, advantages may be gained by careful selections in the pickled state, before commitment to tannage or a specific type of leather.

A third option is to use a very acid/salt pickle as a means of preservation.

Acid/salt pickle for preservation

Pickling in a processing vessel.

Pickled skins after discharge awaiting stacking and draining.

- At times of feasting the massive volume of skins available is too great to be fully processed.
- Accordingly, skins are either preserved, or processed to the pickled state.
- Pickling may take place at the tannery, but is often performed by small enterprises near to major collection points, with subsequent sales to tanners.
- Tanners can influence these small scale operations, but inevitably there are variations in processing.

After pickle storage, each skin may require opening before fleshing.

Sometimes, a considerable quantity of flesh needs cutting from the skin.

- It may be that on receipt by the tannery, that the pickled skins have been poorly fleshed.
- These skins are wet back using a salt solution to prevent acid swelling.
- They are then stacked to drain, covered with polythene to prevent drying of the peripheral skin parts.
- Once drained the skins are opened and hand stretched.
- They are then fleshed, with various fleshing machine options.
- This provides advantages in both grain quality and area extension.

Centrifuge for spin drying pickled skins.

Dewatered skins before *(left)* and after *(right)* a light drum tumbling.

- Another option is to bundle the rewetted skins and spin dry in a centrifuge.
- These damp bundles may then be opened manually or tumbled in a drum to remove creases and open before pickled fleshing.

Many gradings according to end use.

Long term storage is possible without deterioration.

- The pickled stock is subject to many selections and gradings.
- These include area, potential substance, quality and final leather type.
- If the pickling process is sufficiently acidic, the skins can be sealed in polythene and held under cool conditions.
- Holding times of around three months before any change in properties.

The manufacture of four different leather types are described:

1] Full grain shoe upper leathers from hair sheep skins.
2] Suede shoe upper leathers from goat skins.
3] Clothing leathers.
4] Gloving leathers.

There will be some cross-over between the different technologies, but these examples provide reasonable overview.

1] Full grain shoe upper leathers from hair sheep skins

Skins being discharged after chrome tannage*.

Skins carefully stacked to drain without creating creases.

- Skins from pickle preservation may be around pH 1.0.
- This is too acid for direct tannage, so they are de-pickled to near neutral – usually pH 6.5.
- They are then re-pickled as required in preparation for tannage*.
- Alternatively, they may be pickled and tanned directly after deliming and bating.
- After tannage, the skins are unloaded and piled.
- They are left to drain for one or two days covered in polythene to prevent surface drying.

*(*also wet white and vegetable tannage according to end-use.)*

Light samm or samm/setting small skins.

Continuous grading required for small skins to maximise value.

- The damp skins are then (re)assessed/graded for substance, area, and quality.
- This may include suitability for leather types other than shoe uppers.
- These various options for end-use within a tannery are a significant part of viable production.

Feed to wet staking to open creases in the shank parts.

Shanks well opened following wet staking.

- Wet blue for footwear may be lightly sammed to dewater and to slightly consolidate the structure.
- The tanned skins may be opened by hand, but wet staking *(wet-stretching)* can be used in preparation for shaving.
- This operation stretches the structure, and creates a flatter and smoother grain layer.
- In particular, it is necessary to open the creases in the shank parts to reduce the amount of cutting damage on shaving.

Careful attention when shaving to sometimes very low substances.

Buffing loose fibres from the flesh parts after shaving.

- The skins are then shaved to substance.
- They may then be cylinder buffed to clean loose fibre from the flesh side.
- These machines comprise a fast rotating straight cylinder with grit of uniform size stuck to the surface, or covered in emery abrasive paper.
- The skin is held manually across this rotating cylinder.
- The action abrades and extends the structure.

Out-feed from a setting operation.

Vacuum drying is the usual drying option as it develops a tight grain.

- The skins are retanned and dyed, then piled to drain.
- They may then be lightly samm/set or set.
- Drying is usually by vacuum drier, followed by an overnight lay to equalise the moisture content before staking.
- After staking, if the skins are of high substance, drying is completed by suspension drying.

Off take of sheepskin leathers after vibration staking.

Cylinder polishing lightly waxed leather in finishing.

- Softening is normally by vibration staking.
- The skins are inspected in the crust condition before entering finishing.
- Finishing can be moderately heavy for the higher substance skins and fairly similar to bovine procedures.
- Leathers of lighter substances can only support light finishes.

Leather of lighter substance cannot support a heavy finish.

A wide range of footwear can be manufactured from small skins.

- Where finishing is minimal with little cover, the dyeing needs to be intense and accurate to shade.
- The fine grain structure lends itself to classic aniline-type finishes.
- However, the range is not restricted to dress and high fashion, and the scope includes casual footwear manufacture too.

2] Goat skin manufacture for suede shoe upper leather

Trimming to avoid tangling in retanning and fatliquoring processes.

Tension-free drying for softness and tightening the flesh fibre structure.

- A one-day soak and hair burn liming process is often used, as goat hair usually has no value.
- Otherwise, processing to the pickled and tanned state is similar to hair sheep.
- Shaved skins are trimmed to remove damaged peripheral parts, and buffed on the flesh side.
- Then retanned and fatliquored only, without a dye addition.
- They may be piled and drained for 48 hours to drain.
- This is followed by a slow, tension-free drying at low temperature to staking moisture content.

There are many configurations of the cylinder staking machine.

The degree of buffing is dependant upon the individual skin structure.

- Softening may be by vibration staking, followed by cylinder staking and extension.
- The cylinder staking machine is similar in configuration to the reverse-action samm/setting machine.
- The conveyor feed roller and support rollers are hard, but a short felt feed belt is often fitted to assist the forward and reverse action used.
- The undyed crust skins are then buffed.

A second tension-free drying to preserve a fine nap.

Presentation suede side up on expanding toggle frames.

- Buffing includes careful inspection and/or rebuffing to ensure a fine and uniform suede surface.
- These skins are wet back and dyed to shade.
- Piled to drain, but covered in polythene to avoid surface drying.
- Tension-free drying, followed by milling to soften and raise the nap.
- A final toggle dry suede side up, with the extension providing flatness and softening.
- Inspect and dispatch.

3] Hair sheep for clothing leather

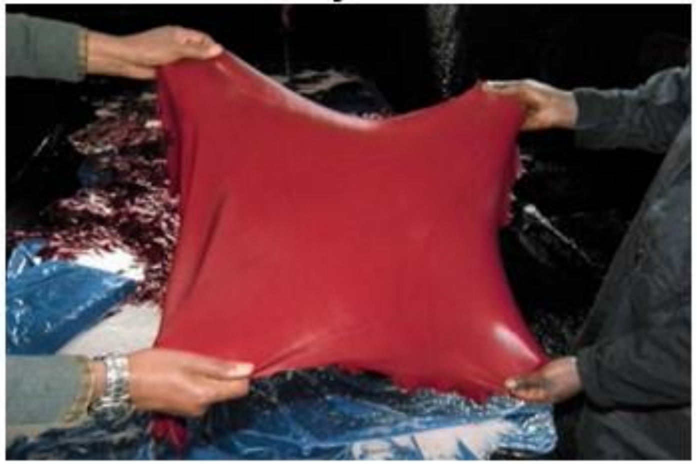
Selections of dry undyed leather *(crust selections)*.

Dry shaving – particular attention to substance.

- After tanning, the skins are drained for 48-hours to provide a consistent weight for chemical weighing, and to avoid compression *(firming)* of the structure.
- Retannage and fatliquoring, without any dyestuffs.
- After unloading, drain for 24-48 hours, then set on the grain side and dry-tension free.
- Condition if needed, soften, extend and flatten using a cylinder staking machine.
- Select for quality, size, potential substance.
- Dry shave.

Buffing or wet wheeling before dyeing to clean the flesh structure.

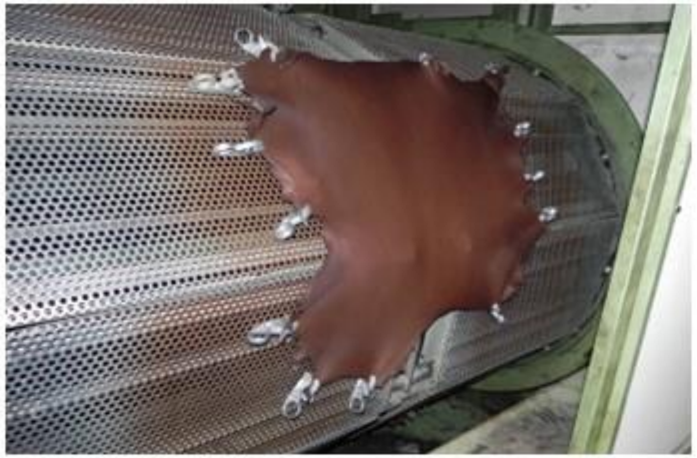
Dyeing crust leather provides both colour uniformity and softness.



- Once shaved, and before dyeing, the skins may be cylinder buffed on the flesh side.
- Alternatively, a rotating wheel covered with an abrasive grit is used to clean the flesh side.
- Known as wet wheeling, the cross- section of this wheel is rounded instead of flat.
- This is especially useful in extending the flanks.
- The skins are then returned to the dyeing department, wet back and dyed to shade.

Setting before tension free-drying.

Toggling after milling to flatten, extend and soften.



- After dyeing, unload, drain for 24 hours, then set on the grain side and hang dry without tension.
- Condition if needed, then soften and extend using a cylinder staking machine or dry wheeling.
- Mill if required for extra softening or texturing.
- Toggle.

Leathers that have been processed to the crust state, then dyed, provide very level surface colour with good dye penetration.

This is technically important as finishes are very light for protection and to enhance the grain appearance.

Dyeing needs to be very precise because of the lack of cover on finishing.

An alternative approach:

Continuous attention to substance measurement on shaving.

Leathers dyed black in high volume may allow a degree of rationalisation.

- An alternative technique is to lightly samm the tanned skins and shave to substance.
- They may then be cylinder buffed or dry wheeled to clean the flesh side.
- They are then dyed, retanned and fatliquored, hang-dry, staked, and/or tumble, toggle.
- This avoids crusting procedures.
- Rationalisation of this type is common where the volume of one colour/texture is particularly great.

Sometimes, If the production is predominantly black, shaving in the tanned state is omitted.

Skins are selected for potential substance, retanned/fatliquored/dyed and dried.

At crust sorting, judgements include the creation of batches according to the potential shaving substance.

Skins are then dry shaved, providing a very accurate substance.

This makes the best use of raw materials in terms of maximum substance that can be extracted from each skin.

The technique provides savings in labour costs and reduces plant use, but the downside is the loss/cost of processing chemicals as shavings.

4] Hair sheep for gloving leathers

Classic slow, cool and tension-free drying for the softest leathers.

Careful grading, with specific attention to substance.

- Manufacture is similar to clothing leathers.
- Once selected according to size, thickness and quality, the skins are processed to the crust state.
- They are again subject to careful grading for substance and quality.
- They can then be dry shaved.
- The substances may be as low as 0.5 +/- 0.05 mm for ladies, and 0.6 +/- 0.05 mm for mens gloves.
- Once shaved they may be cylinder buffed, or dry wheeled to clean the flesh side and extend the shanks.

Tension-free drying for the highest degree of substance and softness.

Each skin is wheel staked according to softening needs.

- After dyeing to shade, and draining, the skins are hang dried to conditioned moisture content.
- They may be cylinder staked, tumbled, and toggle dried.
- Wheel staking may also be used to soften and extend.
- In this operation the skins are held in place against the machine body by pressure applied by the operative.
- The skin is stretched by blunt blades mounted on a rotating cylinder. The application of pressure is controlled by use of a hand pad.

After buffing, there is considerable attention to dust removal.

Wide range of finishes and textures within fashion.

- Buffing may take place on the flesh side for better presentation and to extend and soften.
- Dust is thoroughly removed before entering finishing.
- There are many options in post shaving procedures.
- Final uses may be as varied as white golfing gloves, within high fashion and certain industrial uses.

Additional: Wool-bearing sheep skins for full grain leather

Paddles are required for soaking to avoid matting and wool damage.

Once de-wooled, drums may be used with care for grain leathers.

- **Heavy yielding wool-bearing sheepskins have a relatively thick and open structure for the skin size*.**
- **The skin substance may be sufficient to enable splitting.**
- **Mature skins at higher substances suit light footwear manufacture.**
- **In retannage, the structure needs a high level of filling in the corium, and support at the junction.**
- **This provides shape retention in footwear components, and grain tightening.**

[*Structural differences, including high natural grease content, ref: Part 8]

Soft naturally textured leathers for jackets and full length coats.

Reproduction of 19th century desk: Fold-down work top - leather inset.

- Other uses for wool-bearing sheep skins include slipper-type footwear, for ultimate comfort.
- They can make very soft grain leathers, especially lambskins for the highest quality garments.

++++

- There are many other uses for small skins too: bags, high value furniture and fittings, and leather goods.
- Specialist products, such as chamois and cricket ball leathers.

Review

Over and above quality issues, there is considerable variation in both area and thickness of raw skins. And with minimum splitting options, there can be considerable substrate waste on shaving.

This favours a production mix of two or three different leather types - shoe upper leathers, clothing and gloving leathers - at their different substances.

These have different technical requirements.

Over and above technical issues, the key is grading and re-sorting to extract the greatest potential from each skin.

For shoe upper leathers, in broad terms, skin manufacture has similarities to bovine manufacture of leather at low substances.

The processing and drying is mainly based on a light samm/setting and a short vacuum drying at low temperature to create a compact structure.

Finishing may be relatively heavy, but where the grain has high quality its fine structure can be enhanced by very light finishes that are reliant upon good dyeing.

For clothing and gloving purposes, after tannage and retannage, leathers are often drained to remove water to avoid fibre compression and firming resulting from samming or samm/setting operations. This is followed by a slow tension-free drying.

The lack of compression of the structure and ability to relax on drying creates a soft leather with a very open fibre structure.

This configuration is very permanent, but enables further softening by mechanical operations in crust manufacture. This soft and open structure can be retained if the crust stock is rewetted for dyeing purposes, and through second time drying.

Very uniform colour can be provided by crust dyeing, and easy penetration throughout the structure. This is required for light leathers with a minimum finish.

Several specialised machines are involved in small skin operations to provide cleaning and softening.

Wheeling, cylinder buffing and cylinder/wheel staking machines are used to remove fibres from the flesh and to soften. They are also very important for extending the skins and assist a reshaping into a flattened structure.

Due to the small area of each skin, the considerable handling, and the need for individual attention and manipulation of each piece, these operations are very labour intensive.

Continues as:

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 7)

Small skins: wool bearing sheep double face (two face), shearlings, and rugs

Author: Richard P. Daniels

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Leather: AN OVERVIEW OF MANUFACTURE

Content and Structure:

This section includes a summary of hides and skins as raw materials.

Part 1: The removal of unwanted materials and extension of the structure.

Part 2: The introduction of new materials and extension of the structure.

Part 3: The removal of water and reconfiguration to a flat form.

Part 4: Application of the finish.

Part 5: Different types of bovine leathers.

Part 6: Small skins: hair sheep and goat: grain leathers.

Part 7: Small skins: wool bearing sheep: double face, shearling and rugs.

Part 8: Discussion.

Annex.

The manufacture of wool skin leathers

For the manufacture of two face *(or double face*) leathers, shearlings and rugs, the following matters need taking into account:

1] Skin collection, preservation and supply.

2] Structural differences.

3] Technical issues.

4] Value.

1] Skin collection, preservation and supply

Wool sheep originate often from large scale enterprise, with more centralised slaughter and preservation than hair sheep and goat.

Slaughter is not influenced by tradition to the same degree as hair sheep and goat, nevertheless, there are times of surplus and shortage, and this affects availability and supply.

The methods of preservation are mostly wet salting or dry salting, with global sales and movement.

There are frequently long storage times before manufacture.

2] Structural differences

These sheep have been bred for wool and meat. The fleeces are considerably greater in weight and volume than the coarse hair found on hair sheep and goat.

Accordingly, the skin structure is different too. It is thick, but relatively delicate, and may have a fat content of around 20% on the raw skin weight.

This influences the way that the leather is made. The skins are weaker and can be more easily torn in processing. There are more voids too, especially after the removal of fat held within the structure.

Over and above the importance of the skin structure, the predominant factor is the considerable quantity of wool when leather processing compared to the skin weight.

This wool is of high value, and can easily become matted or felted.

3] Technical issues

In manufacture, to reduce the stress on the skins and to reduce the problems of felting, it is essential to use very high floats when compared to other types of leather manufacture. The floats used may be as high as 500% as opposed to 50 – 150% for most other leather types.

The unhairing process is omitted too, with an absence of any high alkali treatment to avoid coarsening of the wool texture. As a consequence, there is no alkali swelling of the skin, or solubilisation of unstructured proteins as achieved in liming. Alternative techniques are needed to soften and extend the collagen structure.

In addition, the release of natural fats is hindered as the fat cells remain more intact. Other techniques have to be used as the natural fat content can be considerable.

The machinery employed is often suited to small skin grain leathers, but there is a need for specialised equipment to address the wool component. In addition, paddles and small skin processors operating at high float levels are required in the place of conventional drums.

4] Value

The major issue is to retain the quality of the wool, and avoid any wool slip. The value of the recovered wool after sheared to a specific length, is very significant.

The structure of wool-bearing sheep

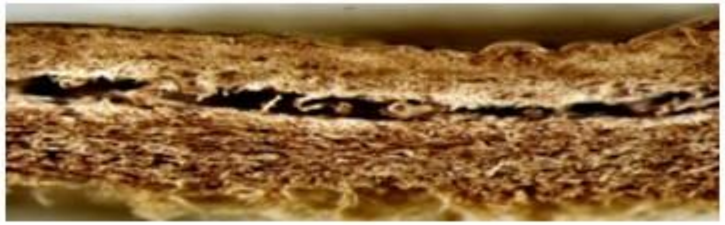
Mixed flock of goat and hair sheep.

Wool-bearing sheep.

- There are clear differences between hair sheep and wool-bearing sheep.
- This is due to selective breeding, animal husbandry, feed, and the environment.
- Hair sheep are bred for milk and meat, with a structure more similar to goat skins.
- Wool-bearing breeds are bred with focus on the wool value and meat.
- The weight of the wool has a significant effect on the skin structure.

Section of leather from hair sheep.

Section of leather from wool- bearing sheep showing delamination.



- The structure of hair sheep skin is very dense when compared to a typical wool-bearing example.
- Due to the weight of the wool carried by the sheep, and a high fat content, the structure is weak.
- Much of the fat is carried at the junction between the grain layer and the corium.
- Too much stress in manufacture, or over-opening of the structure can readily cause delamination.

(Sections shown from final leathers - detail clearer than examples from raw skin)

Wool sheep skins leathers

The manufacture of three types of wool skins are described:

1] Two-face (double face), that is, high quality wool bearing, with a suede flesh side, used for footwear and various types of clothing.

2] Shearlings, generally lower quality and used for linings and industrial purposes.

3] Rugs.

Much of the processing is similar in the initial stages, but with variations after pickle and tannage to the final state according the end use.

Success is dependent upon the detail of processing. In particular, care is needed to avoid wool tangling/matting, and within both wool and leather dyeings.

1] The manufacture of two face (double face) sheepskins

Gentle action of rotating paddles blades maintain skins in suspension.

Processors: greater mechanical action, but various loadings possible.

- **To avoid wool matting, and to minimise stress on the skin, mechanical action through wet chemical processing is minimal.**
- **This means extensive use of paddles.**
- **These operate at very high float levels when compared to drums, and operate at a fixed volume.**
- **Processors of various construction are used too, where different loadings of skins and high floats can be managed safely.**

Raw materials

Long wool sheep, wet salted from sub-artic region of Europe.

Dry salted sheep from China being tumbled to remove surplus salt.

- To off-set fluctuations in annual supply, large raw stocks are commonly held by tanners.
- The different species and environments produce different wool types and skin size.
- Sorting and grading is key for end-use. Often double face, shearlings, rugs and nappa are produced within the same tannery.
- Trimming is essential to avoid skin tangling and resultant wool matting.

Soaking and first time fleshing

High rate water feeds are required where high floats are used.

Removal of flesh and fat on first time fleshing of sheepskins.

- The objective of the first soak is to remove dirt from the wool and partially rehydrate the skin structure.
- The soaking time varies according to the preservation method.
- The skins do not need to be fully soaked, as some firmness is needed to improve the cutting action on first time fleshing.
- A considerable amount of fat can be removed at this fleshing stage.

Wool washing (scouring)

Discharged of wool skins following a processor based scouring process.

Centrifuge for removal of water from the wool and skin.

- After fleshing, the skins are lightly scoured to remove dirt and grease from the wool.
- The process uses a blend of wetting agents and sodium carbonate to adjust the pH to mildly alkali conditions.
- It may be that enzymes are used within this processing.
- Spin drying is mainly used to de-water and avoid any compression.
- In preparation for wool shearing, a mechanical combing may be used to free tangles and debris from the wool.

Feed to the shearing machine fitted with a mesh conveyor belt.

Wool skin following shearing of the butt area.

- The wool is then sheared to a uniform length.
- This is slightly longer than the final length, as accuracy is only possible when dry.
- On machine offer, the skin is held firmly to the mesh conveyor belt by vacuum.
- At the time of cutting, the wool is raised and extended by suction.

Hand shearing around the skin after mechanical shearing.

Exceptionally clean/extended flesh layer from second time fleshing.

- The wool around the skin edge is held flat to the belt by the vacuum during shearing, and remains largely uncut.
- This surplus is removed to length by hand shearing.
- With the wool at a uniform length, a very effective second time fleshing is possible.
- This provides a very clean flesh part, and more grease removal.
- The heavy mechanical action also extends the skin.
- Without the benefit of softening from liming, extension is a key part of skin softening.

Chemical offers are based on float concentrations not skin weight.

Drainings from pickle stacking are mostly collected for reuse *(recycling)*.

- The pickle process can be preceded by a bating stage.
- A sulfuric/formic/salt pickle is generally used, but other organic acids may replace formic acid.
- Once complete, the skins may be stacked down for several days to drain, thus avoiding compression of the wool and structure.
- This laying period allows some acid breakdown *(hydrolysis)* of the collagen structure too.
- The resultant softening is influenced by temperature, time and choice of organic acid.
- This part-compensates for the lack of a liming process.

Reloading paddles on completion of laying period after pickle.

After degreasing, the skins are tanned, then stacked to drain.

- A degreasing process is required after pickle and before tanning.
- There are several options according to grease content.
- For skins with low grease content, a de-acidification to neutral pH, followed by emulsification with wetting agent may suffice.
- A more usual technique is to raise the shrinkage temperature by a light pre-tan, often with a modified form of glutaraldehyde.
- The temperature can then be raised to soften/melt the grease, coupled with emulsification by wetting agent.
- This grease removal is enhanced by the extended laying period after pickle.

Wet wheeling: reliant upon grit size and pressure applied by the operative.

Retannage and fatliquoring using either paddles or processing vessels.

- Once tanned, dewatering by draining or a light samm/setting.
- The flesh side is then wet wheeled.
- This operation abrades flesh residues from the shank and belly parts, and cleans the flesh side.
- It is part of making a uniform surface across the flesh part.
- It also causes a stretching and softening of the structure.
- On retannage, the focus is to develop a fine and consistent flesh structure suitable for level dyeings.
- The choice of fatliquors must favour a retention within the structure throughout a subsequent dry cleaning operation.

Skins may be spin dried in preparation for 1st time drying operations.

Setting is used to extend the skins without causing fibre compression.

- After retanning and fatliquoring the skins are washed and stacked to drain.
- This may be followed by centrifuging to part dewater the wool and pelt.
- They may then be lightly set on the flesh side to extend the skin in preparation for drying.

Tension free suspension drying for maximum softening.

Spray conditioning in preparation for mechanical operations.

- Once set, the skins can be suspension dried.
- This usually by free hanging using a conventional horizontal pole system.
- Alternatively, cabinets with the advantage of controlled temperature and RH.
- The drying is usually to around 12% moisture content.
- After a laying period, the skins are lightly conditioned by water spray.

Example of a ridged setting cylinder arrangement used for softening.

Top left: wool before shearing, lower left: wool after shearing.

- Staking is mainly based on cylinder arrangements that on rotation extend and apply a setting action to the flesh parts.
- There are many different machine configurations.
- The wool may then be sheared to a more precise length in preparations for ironing and straightening.

Cylinder of a small combined combing and ironing machine.

Wool before and after a combined combing and ironing.

- The wool is combed and ironed at raised temperature.
- This can include a wool straightening stage.
- This commences with a acid/alcohol spray to soften the wool, then extension by hot ironing.
- The spray may be incorporated within the ironing operation.

Industrial dry cleaning equipment used for grease removal.

Several buffings may be needed to form a high quality suede structure.

- The wool may then be re-sheared to create a very precise length.
- This may be followed by a dry cleaning using perchlorethylene to remove residual natural grease.
- Performed at raised temperature, the skins need a low moisture content to avoid shrinkage.
- Solvents are recovered for reuse.
- Recovered grease may be sold or used as boiler fuel.
- The skins are then lightly conditioned before buffing.
- Buffing is a particularly important to develop a clean and uniform nap in preparation for dyeing.

Paddle dyeing well open and free-flowing wool sheep skins.

Wool and suede may also be dyed in colour combinations.

- Dyeing is performed in paddles or processors using high floats.
- The uptake and development of colour is strongly influenced by previous processes.
- The wool is dyed first, using dyestuffs that favours wool fixation instead of the sueded side.
- The leather is then dyed to shade.
- It is also possible to dye the leather with the wool remaining undyed.
- These dyeings are more complex than either wool dyeing or leather dyeing alone.
- Risks of cross-uptake of the dyestuffs need taking into close account.

Setting and toggling produces a flat and firmer structure.

A light toggling may be used after hang drying to flatten and extend.

- Dependant upon the degree of softness required, after draining, the skins may be set, then toggle dried.
- For the softest result, they may be drained (or centrifuged) then hang or suspension dried.
- These operations are followed by conditioning, and restaking.
- The wool may receive a final iron, shear, and re-polish.
- If the skins have been suspension dried then a light toggling to shape.
- Many combinations of technique are possible.

Classic double face: a combination of fine wool and suede dyeings.

Aniline type finish on wool skin – an alternative to suede.

- This may complete processing for double face - a high quality wool skin, combined with a fine suede leather.
- However, the suede side may be finished.
- It can involve sealing the sueded surface then creating a light aniline type finish.
- It may be that transfers, or ultra fine laminations are used to create effects.

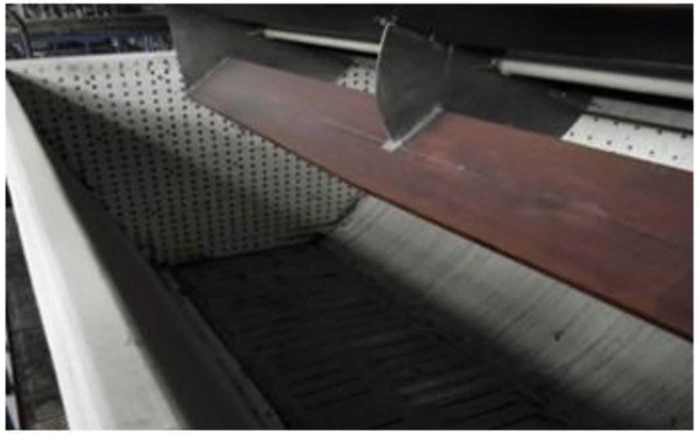
2] The manufacture of shearlings

Many selections for skin and wool quality crucial to maximise potential.

Focus for mechanical softening on the flesh side.

- Manufacture follows the same basic processing as double face to the retanning and fatliquoring processes.
- However, at the time of tannage there may be high additions of stable fatliquor.
- A clean flesh side is needed, but there is not the high emphasis as required for a fine suede surface.
- If the wool and leather structures require a natural appearance, preparations for the most pristine dyeings are not needed.
- In this situation, these wool skins are not wet back after drying or subject to further chemical processing.
- Post drying operations vary according to end use.

Paddles may be fitted with false interiors to facilitate drainage.



Interiors may elevate and tilt to assist unloading after drainage.

- As with double face, care and attention is needed to maintain the wool in the optimum state.
- In tannage, retan and fatliquoring, the floats are very high.
- These processes can therefore be chemically inefficient, however, there is considerable scope for chemical and water savings.
- With standard tanning processes - especially natural *(undyed)* processing - recycling can be very viable.
- On discharge floats can be collected, screened, and made up to concentration for re-use.
- There are many options to save chemicals, water, and energy.

3] The manufacture of rugs

Undyed aldehyde/aluminium and chrome tanned woolskins.

Continuous attention to eliminate tangling and enhance appearance.

For the most basic processing:

- The wool may be left unsheared.
- There may be an extended lay period in the pickled state *(considerable variations: 3 -10 days)* to develop softening.
- Chrome, aldehyde/aluminium combinations and veg tannages are used to create leathers with "natural" appearance.
- Heavy reliance upon a combined tanning and fatliquoring process.
- On small scale, a hand application of fatliquor on the flesh parts may take place after tannage.
- Longer laying periods for draining are used to avoid mechanical action.

Final care and attention to detail.

Many different types of wool textures and effects.

- **Extensive wheeling is reduced: a clean flesh is needed, but not fineness to the extent of double face and shearlings.**
- **Post drying operations are less intensive that for double face.**

For the highest value products:

- **Most of the elements of double face manufacture are included.**
- **May involve special wool dyeing effects, with high focus on the wool structure after drying.**
- **Wool textures can be developed in finishing for ultra smoothness, sheen and silkiness to touch.**

The value of wool

Recovered wool - washed, drained, dried and graded for sale.

Wool recovery is essential at both cottage and major scale.

- **Attention to the quality and value of wool is central to success in wool skin manufacture.**
- **And the requirements for fine wool processing are not always the best for leather manufacture.**
- **Also, the properties of the raw skin are a consequence of a requirement for wool.**
- **These factors create limitations for making these often conflicting combinations work.**
- **When sheared or removed intact in leather processing, wool recovery is essential.**
- **Wool is a major component in the viability of wool-bearing sheep skin manufacture.**

Review

Although the most basic leather-making stages are comparable, the manufacturing finesse required by small skins differs strongly from the needs of bovine hides.

The equipment required for skins is smaller and lighter, often with specialised purpose. Chemical applications are different too, and a higher level of individual attention is demanded by the smaller pieces.

Mechanical actions, chemical processes and handling reflect the differences in structure and end-use.

There is also variation in raw material supplies in terms of volume and quality that is not experienced in bovine manufacture.

There are quite different objectives within small skin manufacture too:

- For grain leather manufacture, the aesthetic value of the grain layer is of main concern. The tightness and break characteristics, a defect free grain, and levelness of appearance and colour.
- For wool skins, the focus is to develop the wool characteristics to specification. The leather needs to be soft and tactile, but with emphasis on the flesh part as opposed to the grain. The appearance and handle of the flesh part – either suede or supporting a finish - must complement the appearance and texture of the wool.

There are five issues in particular when comparing the processing of wool bearing sheep skins to hair sheep:

- The structure is comparatively weak.
- There is a high grease content that must be removed.
- The wool must be retained intact.
- High alkali treatment – such as liming – must be avoided, although the leather must be soft.
- The requirements for wool processing are often detrimental to good leather making.

To address these needs there is a need for:

- Use of paddles and skin processors operating at a high float, with minimal mechanical action throughout chemical processes.
- A softening of the structure that may involve an extended pickle based on selected organic acids.
- Heavy application of force in machine operations to extend the structure as part of the softening process.
- Aqueous degreasing processes to remove grease from both the wool and skin structure, mainly coupled with solvent degreasing.
- Very specialised dyeings, with different requirements for both the wool and skin.
- A heavy focus on the wool component throughout all operations.

Continues as:

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(Part 8)

Discussion

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Part 7: Small skins: wool bearing sheep: double face, shearling and rugs.

Part 8: <u>Discussion.</u>

Annex.

This Part serves as a review of the whole content of this study, and 30 issues are raised. These are mainly based on frequently asked questions raised by counterparts, and students within formal education. It is suggested that each is considered in turn, then compared with the response that follows.

Being a complex industry, often there is no single answer to any of the issues. Sometimes, the responses bring together information from several Parts, thus providing an expansion of technical detail.

It is clear that more can be said, but leather making is a technology, and not pure science.

The focus of “Overview” is self-study for technicians, but its design enables uses within formal education. If this Part is managed by a moderator with leather making experience, the various issues and responses can serve as base for group discussions.

1: Issue

Hides and skins from cattle, sheep and goat are the manufacturing base for leather. As raw materials, what are their main problems ?

1: Response

Hides and skins originate from animals raised and husbanded for milk and dairy products, wool and meat production.

These are very specific purposes, and do not take into account the needs of leather manufacture.

Various forms of damage can occur during the life of the animal, and at times of flaying and removal from the carcass.

Hides and skins are ultimately a waste product from the food industry.

They are subject to rapid deterioration and decay, unless they are processed very soon after removal from the carcass, or preserved in some way.

2: Issue

What advantages are offered by processing fresh hides and skins, rather than in a preserved state ?

2: Response

Managed correctly, fresh hides and skins can remain free from decay and, with the possible exclusion of ice for chilling purposes, avoid any chemical contamination.

For longer term preservation, salting is a highly effective option, but the salt requirement is high and raises issues of salinity in wastewater treatment. The use of salt in preservation assists the release of grease within the early stages of process too. The leathers may be slightly softer and more relaxed than fresh hides.

In dry salting, the low salt applications are sufficient to inhibit bacterial action in the early stages of preservation, then supported for long term preservation by air drying. This can provide better quality leathers than air drying alone.

Air drying provides excellent long term preservation. The reduction in moisture content of raw skins from around 65% to 12%, reduces weight in transport, hence costs. However, the skins are slow to rehydrate, tend to be slightly firmer than when freshly processed, and can suffer bacterial damage arising from within the drying phase.

Acid pickling options are also an excellent technique for small skins. Processing to the pickled state can be managed by small operations with basic equipment. Pickled skins can be kept for many months, especially if stored at a low temperature. For small skins, where the raw material supply is very spasmodic, this can be a more effective option than air drying or dry salting.

3: Issue

Why is it important to fully rehydrate hides and skins before chemical processing ?

3: Response

Full rehydration enables the most uniform penetration of chemicals during liming that is possible.

If parts of the structure are not soaked properly, then the swelling effects during liming are irregular, and this leads to distortions within the structure.

The reduction of growth marks in the neck areas, and draw or fine wrinkling in the belly parts is not as effective as otherwise possible.

However, if the soaking is too long *(oversoaking)* then there are dangers of the final leather being looser, especially in the belly parts.

4: Issue

Green fleshing – that is fleshing before liming – is often omitted.

What does this operation offer to leather making ?

4: Response

Even if the residual flesh is minimal, it forms a barrier that inhibits an even penetration of liming chemicals into the structure.

In turn, this creates irregularities in outcome that can affect subsequent processes.

Even in the best situations, the structure is not uniform due to variations in thickness, density and deposits of fats. The presence of flesh is yet another unwanted variation, but this can be eliminated.

There is also a reduction in the weight of the load entering liming, hence a saving in the chemicals, and subsequently a reduction in wastewater treatment.

If the recovered flesh is unswollen and in a non-alkaline state, it is more readily used for other purposes.

5: Issue

Hides and skins can be fleshed before liming, after liming, and for small skins even in the pickled state before tanning. The intent of these operations is to remove residual flesh, and to stretch and relax the structure.

What else occurs in limed fleshing that does not take place in the other two situations ?

5: Response

Considerable pressure is needed to hold the hides and skins securely between the transport and grip rollers as the cutting action takes place.

This compresses the structure, and squeezes water containing proteins that have degenerated in liming, fats, hair roots and pigmentation from the grain layer.

It is part of producing a cleaner grain surface.

6: Issue

What are the advantages of limed splitting ?

6: Response

Limed splitting provides a relatively thin grain split of reasonably level substance. This enables a fast and uniform release of residual products in deliming, and uniform penetration of chemicals in bating, pickle and tannage.

Only the grain layer is processed into the tanned state, and this means less weight for processing to this stage. This ensures a significant reduction in chemicals offered to process, and a reduced load for wastewater treatment.

It also means that the thinner grain section is more readily extended in processes and operations pre-shaving.

If the flesh split is trimmed for processing into leather, then the trimmings are uncontaminated by tanning materials. If the splits are not for tanning, then the untrimmed split is suitable for food manufacture, gelatine or bio-gas production.

7: Issue

Why should particular attention be given to the deliming process ?

7: Response

The deliming process is the major step between the change from a high alkali state into acidic conditions used for pickling.

This lowering of alkalinity to near neutral conditions is accompanied by a reduction in swelling, and water is released from within the structure. This water contains proteins that have been solubilised in the liming process. If they are not removed, at later stages they cause adhesions of the fibres and firming.

This process is usually monitored for full removal of alkali by spotting the section with phenol phthalein solution which reveals residual alkalinity as a pink colouration. However, there are two issues that need taking into account:

i] The cuttings need taking from the parts of the skin that are the most difficult to delime: that includes the thicker neck section, particularly where there are growth marks.

ii] Even if the indicators show complete deliming, more time is needed for complete release of the residual proteins from the centre parts.

The process also creates mildly alkaline conditions that suit good enzyme activity in bating. In this process part of the collagen structure is modified to cause a softening effect in the final leather. Both deliming and bating cause relaxation and help the release of pigmentation from the grain layer.

8: Issue

The acid / salt pickle is a major step in the preparation of hides and skins for tannage. Control of pH is essential to manage the penetration of the selected tanning agent into the collagen structure before fixation and tannage.

What is the role of salt in this operation ?

8: Response

If common salt is absent in the acid pickle, then acid swelling will occur. In the shift from neutral to high pH conditions in liming, soaked hides and skins swell by approximately 20% due to water uptake. Similarly, swelling occurs if the pH of delimed and bated pieces is shifted from around neutral towards low pH conditions.

Even if subjected to moderate acid conditions - pH 3.5 to 3.7 - the resulting leather will be firm with a hard grain structure.

The addition of common salt will reduce these effects, ensuring tannage in a relatively non-swollen state.

It is noted that other salts - such as sodium sulfate - can be used to suppress swelling, too, but they also change the properties of the leather.

9: Issue

Acid/salt pickle systems are used in preparation for tanning. They are also used as a method of preservation for sheepskins.

What are the differences ?

9: Response

The acidity of pickles used in preparation for tannage varies according to the tanning system. They are normally based on sulfuric acid with a small amount of formic acid, with added salt to prevent a swelling of the structure.

When pickles are used for preservation, the acidity is much greater *(a lower pH)* than used for tanning, and is based on sulfuric acid and salt. These skins can be kept for significant periods of time without significant change.

These skins normally need depickling as they are very acidic, followed by a conventional acid/salt pickle to suit the tanning technique.

The absence of a weak organic acid in the preservative pickle means it is less likely that mould is an issue for concern, and avoids a softening of the structure.

This softening can be exploited in rug manufacture where wool-retaining sheepskins can be piled for extended periods in the pickled state. The weak organic acid content *(formic, but may include lactic or glycolic acids)* helps compensate for the lack of opening/softening of the structure in liming.

10: Issue

There is no “best” tannage, as they all provide specific properties.

Wet blue leather is very versatile, stable, and has a high shrinkage temperature when fully saturated with water.

But what property makes it so different from other commercial tannages ?

10: Response

Chrome tannage is very cationic, that is, the collagen structure after tanning carries a strong positive charge.

This means that anionic products *(with negative charge)* - most retanning agents, fatliquors and dyestuffs - are fixed within the collagen structure by strong chemical bonds.

This favours a higher uptake of retanning, dyeing and fatliquoring products when compared to other systems.

Lower offers of these chemicals are therefore required, with less wastage as unused products at the end of the process.

This reduces costs in both chemical requirements and the environmental load within wastewater treatment.

11: Issue

The samming operation appears to be a simple means of removing water from saturated leathers after tanning.

It is a relatively slow operation, and unlike fleshing, splitting and shaving does not cut or slice the structure.

Why does it need particular attention ?

11: Response

The objective of samming is to produce a leather in the best state for offer to the shaving operation *(or splitting / shaving if full substance manufacture).*

The structure should be compact, with a consistent moisture content, to maintain good shape retention within splitting and shaving. It needs the correct balance between firmness and softness to optimise the outcome from these operations.

These requirements are controlled by a combination of a relatively slow and gentle compression of the fibre structure, and the final moisture content. Neither of these conditions can be measured accurately, and consistency is managed by frequent inspection.

As the leather is offered to the machine, the operatives should manually open and spread the shanks. This assists the action of the spread roller before application of the samming pressure. This helps to avoid the formation of creases and their compression in the peripheral parts of the hide or skin. If formed, these folds are sliced in either splitting or shaving, and need trimming away as waste.

Where hides have been limed split, the thinner substance can be extended quite substantially by the operatives.

(continued)

The feed is normally grain up, and if the out-feed employs a conveyor, this can incorporate quality selection, automatic substance measurement for thickness potential, and area.

In some situations, where hides are limed split, hides are offered grain side down. High pressure can be applied by the spread roller without damage to the grain, even allowing direct feed to the shaving operation.

The base for all chemical and water additions in neutralising, retanning, dyeing and fatliquoring is the weight of the damp leather.

If the moisture content varies, then the amounts of chemicals offered on the actual weight of the collagen will vary too.

12: Issue

Sorting operations usually occurs after samming.

However, it can take place in the wet tanned state too.

What advantage does this offer ?

12: Response

Many tanneries process hides to the wet blue state only, and quality selections may be made while the hides are still wet.

This is labour intensive, and each hide needs manipulation. However, defects such as vein indentations and small scratches are easier to observe in a non-compressed and saturated state, especially under good quality lighting.

The compression applied by samming often leaves a grain impression from the upper dewatering felt, and this effectively masks small grain defects. If the pressure is relatively heavy, then the dewatering causes a whitening of the grain surface, too, and this makes fault detection even more difficult.

This applies to all types of tannages, and is especially important for lighter weight leathers such as sheep and goat skins. After tannage, these are often drained thoroughly to avoid compression, then assessed for grain quality.

If they are to be sammed lightly or samm/set for shaving, inspection can take place at the time of machine offer by the operative. On outfeed, the skins can be stacked manually or automatically into packs according to grain quality.

13: Issue

The advantages of splitting in the limed state have been considered.

What can be gained by processing hides at full substance to the tanned state ?

13: Response

The main advantage is that the maximum options remain available at sorting pre-splitting/shaving for the substance of the final leathers.

This is very important when there is significant variation in substance requirements for a range of different leather types. For example, when making shoe upper leathers for a mix of, say, mens, ladies and children's footwear, which have different substance specifications.

In addition, the accuracy of splitting can be better in the tanned state than in the limed condition. This means that the splitting substance can be closer to the shaving substance, hence less waste in the form of shavings cut away from the hide.

14: Issue

Can splitting to substance be sufficiently accurate to avoid the shaving operation ?

14: Response

This is possible, but splitting is a delicate operation and may not provide the degree of accuracy required. Moreover, there are other issues to consider apart from uniformity of thickness.

The cutting action on the fibres during shaving provides an opening of the flesh side allowing a more even chemical uptake.

In addition, even if only a small amount of the substance is shaved from the flesh side of the hide or skin, the forces applied via the angled cutting blades stretches the whole structure.

Growth lines and wrinkles are extended at the time of cutting, and this results in a lessening of these defects. The grain layer is extended and flattened against the support roller too.

The outcome is permanent improvement with a smoother and finer grain surface.

15: Issue

Why is neutralising such an important process, and in particular for mineral tannages ?

15: Response

The tanned collagen structure carries a mix of negative and positive charges. Before neutralising, leathers are slightly acidic. A lowering of acidity by the addition of mild alkali in neutralising *(a rise in pH)* reduces the positive charge of the structure.

With a reduced positive charge, the less the attractions and slower the bonding with negative charged products – that is, most retanning agents, dyestuffs and fatliquors. This results in a slower uptake and greater penetration of these products into the structure before fixation.

If there is no neutralisation this uptake is too fast. This results in an irregular fixation of products that is limited to the surface of the structure.

If the neutralisation is 100% through the section, then, with a slow rate of fixation, very deep penetration of selected retanning agents can occur.

If the leather is only partly neutralised - say, with the middle of the leather section remaining at the original acidity - the penetration is limited to the neutralised outer layers.

(continued)

The neutralising process influences the rate of penetration, location and uptake of dyes, retanning and fatliquoring agents.

Accordingly, it affects the levelness of colour, the firmness, break characteristics, and filling throughout the structure.

16: Issue

Beside the neutralising, what other major factors affect dyeing, retanning and fatliquoring process ?

16: Response

There are six factors to take into account:

1. Management of the charge in neutralising – as discussed *(Issue 15)*.
2. The temperature of process. This affects the speed of the chemical reaction. The higher the temperature, the faster the uptake of chemicals.
3. The time of process. The longer the time, the greater the uptake.
4. The concentration of chemicals in the float. The higher the concentration, the better the uptake of products.
5. The float levels. A greater mechanical action increases the speed and depth of penetration of products into the structure.

However:

(continued)

If the float is too low:

i] This can cause poor distribution of chemicals in solution, and prevent uniform contact with the leather in process.

ii] The individual pieces of leather have an increased risk of tangling. Another cause of irregular chemical uptake and penetration.

6. The mechanical action provided by the processing vessel.

i] On rotation, the combination of speed and vessel design influence the stretching, flexing and compression of leather in process.

ii] These are important factors in determining the rate of penetration within the leather structure.

Neutralising, retanning, dyeing and fatliquoring processes are complex. There are numerous combinations of processing conditions, and products that are available.

17: Issue

Do these six factors apply to other parts of wet chemical processing ?

17: Response

All chemical processes are managed by controlling these six factors, although some factors are difficult to change.

For example, the action provided by processing vessels is fixed by design, so change is only possible by adjusting float levels, load weights, and sometimes the speed of rotation. In turn, these adjustments affect the concentration, distribution and penetration of chemicals.

It should be noted that process development takes theory into account. However, the final commercial process is dependent upon progressive trials. Success is dependent upon an understanding of the chemicals used, the way that the plant and equipment is used, and experience gained as the process is developed.

Fortunately, once a process is established, it can be readily controlled to provide a consistent production.

18: Issue

Processing vessels are clearly more than just reaction vessels.

How else do they affect leather manufacture ?

18: Response

Processing vessels apply very significant forces, often for many hours. The pieces are lifted and dropped on rotation, and subjected to continuous stretching, relaxation and compression actions.

These movements depend upon the vessel design, the speed of rotation, the load weight *(there are optimum load weights for all vessels)* and the float levels.

Each time the pieces are stretched and relaxed - from raw hides and skins to the end of chemical processing - a small part of this extension is retained.

This is important, as it is part of a flattening of the leather from the original rounded animal shape.

Defects - such as growth marks in the neck areas and draw lines in the belly section - can be extended and become less prominent.

(continued)

However, if the mechanical action is too high, there is a deterioration in quality.

For this reason, tri-compartmental vessels are widely used for retanning leathers shaved to lower substances. This reduces the risk of over-stressing - or even tearing - the structure.

In addition, whenever there is a firming or compacting of the structure during chemical processing, there is the danger of the formation of creases too.

For example, if the mechanical action is too great when the pieces are in a swollen state in liming, then growth marks and other natural fold lines will become more pronounced. It is a reason for pits being used for *(firm)* heavy vegetable tannages.

19: Issue

Stretching and relaxation cycles have an extending effect on hides and skins when applied over many hours at the time of chemical processing.

Does something similar occur in the short time of machine actions ?

19: Response

Every machine operation has this effect. From green fleshing to samm/setting in preparation for drying.

Every time the pieces are stretched, some of that extension is retained.

It is a key part of the gradual change from an irregular rounded shape to the flattened form.

20: Issue

The different processes and operations have significant effects on the final leather properties. How is the full process best managed ?

20: Response

This is the role of the leather technician. It requires an understanding of what is needed to control the chemical process, but also what is required from the various mechanical operations. Close attention to detail is necessary in both areas as changes can be subtle, and may develop over long periods of time.

It is also important to realise that change in any of the control parameters will have an effect. This may not appear significant at the time of change, but may be very apparent the end product.

Inspection, monitoring and attention to detail at each stage is crucial to ensure consistency.

21: Issue

How are chemical processes established ?

21: Response

There are two ways to establish a chemical process, such as a new retanning/fatliquoring combination:

i] A process is introduced by a chemical supplier. This is usually heavily dependent on use of their products. For success, this a "standard" process has to "work" with the existing plant and machinery. Although the process may prove a success in one tannery, it may fail in a second situation because of different conditions. It might be possible to amend the process, but this can be time consuming.

ii] The process is developed "In-house". This takes into full consideration detailed knowledge of the plant and equipment. Also, a new product may be introduced, but used with selected products that provide known results.

This is the way to achieve the "best" results, but is often a slow process and rarely achieved in a single trial. It needs care and experience - and often time is short !

22: Issue

What are the guidelines for controlling the chemical process ?

22: Response

The detail is outside the scope of this overview. *(see Annex: Leather: THE TECHNOLOGY OF MANUFACTURE)*.

However, there are critical conditions that set limits to what is possible before pieces are tanned and stabilised.

In liming, high but safe alkali conditions at pH 12.4 are provided by lime, although slightly higher alkalinity *(higher pH conditions*) from use of sodium sulfide can be tolerated for relatively short periods of time.

On the acid side – during preparation for tanning – The pH may vary between pH 2.5 and pH 3.0. These are not extremely acidic conditions, but acid swelling must be supressed by the addition of salt to the process.

However, under both sets of conditions, the skin becomes very sensitive to temperature. Safe working conditions are generally taken as 25C: higher temperatures can be managed, but control is very sensitive.

Damage is guaranteed above 30C, starting with breakdown of the sensitive grain layer. And this applies too when warm water is used for washing limed goods, or added in preparation for deliming/bating.

Under mildly alkaline conditions – such as within soak (+/- pH 10.0), or after deliming (pH 7.5 to 8.5) the limits are probably best taken as 35C.

The other factor to take into account is the mechanical action *(Issue 18)*. In particular, when the hides/skins are firm and inflexible in the soaking process, when swollen in liming, during lime washes, and commencing deliming. Movement should be sufficient to move goods in the centre of the pack, but minimise folding/creasing and possible abrasions to the grain layer.

23: Issue

How does the samm/setting operation affect the outcome from drying ?

23: Response

This operation is a combination of samming actions to remove water, and setting actions to extend the leather. The degree that the leather is extended on setting *(the strain)* varies according the moisture content:

i] The wetter the leather from the samming action, the greater the strain that can be developed. However, as the leather relaxes before drying, there is a loss of this strain.

ii] The lower the moisture content after the samming action, the less the strain from a given load, but the longer this strain is retained.

Pressure affects quality too. If the samming pressure is too high, the structure becomes compressed. The leather becomes firmer, and the break may deteriorate.

For this reason, small skins for very soft leathers are often piled to drain to avoid compression.

High pressures from samming pre-shaving can cause problems too. Although thoroughly wetted in subsequent wet chemical processing, compression effects tend to persist.

24: Issue

Pressure is needed in samm/setting for best presentation to drying operations.

This makes the structure more compact and causes fibre adhesions.

Is it possible to minimise achieve the objectives of samm/setting, but with reduced fibre compression ?

24: Response

Wet stretching or wet staking can provide a loosening of a compacted structure, and if used correctly, without causing a deterioration in grain break. This technique can be used after samm/setting and before drying to causes a fibre separation and relaxation throughout the fibre structure. It is also accompanied with a stretching action for area increase.

Similarly, it can be used after a short vacuum drying to overcome the effects of fibre compression.

This loosening is coupled with a softening, and appears to improve the release of water during evaporation drying too.

The operation is not limited to drying areas.

It is used to open the flanks and extend vein marks pre-shaving, and also for softening within finishing. It is widely used in automotive leather production where it can be readily incorporated into machine linkages.

25: Issue

What are the effects of strain and compression within drying operations ?

25: Response

If a particular leather is:

i] Dried without any compression or extension, this will provide the softest result that is possible. The break will be fine, but the leather will be rounded in the flanks parts and not lay flat. It will be plump and provide the lowest area yield.

ii] Heavily strained throughout drying - such as in toggling - the leather will be harder, have a coarser break, and be flatter. The area will be greater, but coupled with a lower substance.

iii] Subjected to moderate strain and compression - such as when part dried in vacuum drying - followed by tension free hanging, produces effects between [i] and [ii]. The vacuum drying phase will provide flatness that is retained through tension free drying.

However, if the compression is too great on vacuum drying, coupled with a high temperature, then the grain can be over-compressed resulting in a poor and splintery break.

26: Issue

What is the role of temperature in drying operations ?

26: Response

The compressions and strain developed in preparation for drying, and within drying, influence the leather characteristics as discussed.

Regardless of the drying method used:

i] If low temperatures are applied throughout drying, the resulting leathers will tend to be softer and have a finer break.

ii] If higher temperature are used, the leathers will be harder, and have a coarser break and handle.

With the exclusion of vacuum drying, water removal by evaporation is strongly affected by the air temperature. However, if the temperature is low, with good circulation, and removal of air from the system, a rapid drying can be achieved by managing the relative humidity.

An equilibrium between water retained throughout the leather structure, and the moisture levels in the air (relative humidity) develops, and this prevents over drying.

27: Issue

Can softness be controlled by staking operations alone ?

27: Response

Considerable softening can be achieved by vibration staking at an optimum moisture content. However, the properties of the leather are strongly influenced by the procedures used before staking.

If too much mechanical force is applied, the leather may soften, but this is at the expense of the break characteristics.

For the best results, all of the processes and operations within leather making should be in balance.

28: Issue

The objective of finishing is to enhance and protect the leather surface to customer requirements.

Why do the properties of leather change so much within finishing ?

28: Response

There are many reasons for change, and the combined effects can be considerable.

As finish is applied, the grain structure is wetted and penetrated for surface bonding. This results in grain swelling and a coarsening of the surface.

Both the grain layer and finish films needs plating/rolling to provide a smooth surface. This requires a combination of heat and pressure, but this causes a compression and hardening of the leather structure too.

The properties of the final leather are influenced by the properties of the finishes applied. Most finishes are continuous films which are different in terms of elasticity/plasticity to crust leathers.

As water is introduced as various wet finish applications are made, drying operations are required. However, water removal is not just limited to the finish film. The leather is dried, too, and this loss of moisture from within the leather causes a hardening of the structure.

Additional:

The objective of “Overview” is to:

i] provide a broad technical study for a complex industry.

ii] establish factors common across an array of different leather types.

iii] highlight specialisation demanded by different raw materials and end-uses.

There are two important areas that lay outside these matters. These are acknowledged as issues 29 and 30.

29: Issue:

Health and Safety matters

The photographs set down in "Overview" were taken between 2000 and 2022. They were mainly selected for insight into certain technical aspects of leather making. However, some of the earlier images do not reflect current good practice in matters of health and safety.

In particular, full protective equipment for operatives should be provided and used, with all issues of health and safety considered of prime importance. Considerable information, expertise and equipment is available to address these issues.

30: Issue:

<u>Recycling and regeneration of residual chemicals from manufacture, the treatment of solid and liquid wastes, energy and water savings.</u>

Matters associated with sustainability are of high importance, and in particular, need addressing as part of chemical processing. This involves careful selection and best use of chemicals, reuse of residual chemicals if possible, and responsible treatment of solid and liquid waste.

These are major innovations, and the leather sector is at the front in these particular issues. A considerable amount of literature is already available for study.

It is noted that as "Overview" was finalised, a more detailed study was started. This is entitled "Leather: THE TECHNOLOGY OF MANUFACTURE" *(see Part 9: Annex),* and is intended for leather technologists.

One objective is to address these issues of sustainability within leather making practicalities.

Continues as:

Leather:

AN OVERVIEW OF MANUFACTURE

(Part 9)

Annex

:

(Version: 2024)

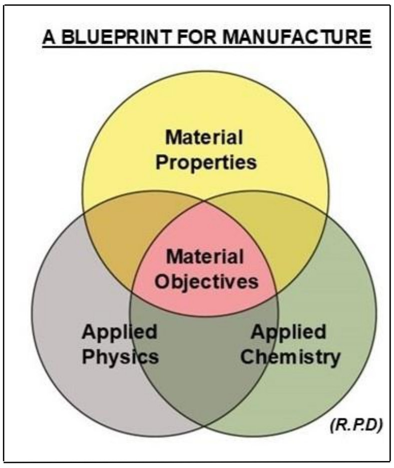
Leather:
AN OVERVIEW OF MANUFACTURE

Annex

Content

Leather: THE TECHNOLOGY OF MANUFACTURE

This study is designed for the Leather Technologist, and builds upon the leather-making information presented in "Overview". It also includes a structure to best understand the requirements of this complex technology.
Here, the three basic components involved in manufacture - "Material Properties", "Applied Physics", and "Applied Chemistry" - are expressed diagrammatically:



In turn, these components are sub-divided into a series of factors, then presented as three inter-related models. The role of each factor is then described in a series of essays, with contributions by specialists in their sectors.
This is a blueprint for the technologist to control, manage, and manipulate procedures to advantage. With supportive information, this is a base for good leather manufacture, and the creation of leathers to specification.

Manufacture: Stages and Procedures

BOVINE HIDES: CHROME TANNAGE: FOOTWEAR LEATHERS

Schematic 1(a) | **Procedures** | *"Overview" ©R.P.Daniels*

Key	Procedures		Information
Mechanical operations Chemical processes Requirements Additional information	Process vessels. (many configurations) All chemical processes	-	Drums, mixer-type, tri- - compartmental vessels. (also pits and paddles)
	v v		
Stage 1 Removal of unwanted components from structure and Extension of the structure	1st Soak	-	Accurate in-put weights. Specific wight ranges.
	v Green flesh v 2nd Soak v Unhair + lime v Lime flesh +/- Lime split	-	+/- Lime splitting Defines grain substance for further processing. Offers high extension of structure throughout all procedures until the completion of tannage. Gives maximum choice for use of the flesh split.
	v Delime Bate	-	Structural relaxation, and release inter-fibre waste.
Stage 2 Introduction of new products into the structure and Extension of the structure	v Pickle Chrome tannage	-	Creation of a versatile multi-purpose tannage.
	v +/- Blue sorting/gradings v Samm v Side	-	+/- Wet sort (pre-samm). Absence of compression and samm indents for clear identification of grain defects.
	v Selection: Blue sort v +/- Blue Split	-	+/- Blue Sort (after samm) Accurate assessment for area and substance. Easier handling and enables rationalisation.
	v Shave v Trim	-	+/- Blue Splitting To maximise substance potential from selections made at blue sorting.
	v Neutralise Dye + fixation Retan Fatliquor/lubricate	-	Development of a wide range of properties to customer specifications.

v

Details set down for broad information only. Variations in procedures required according to materials classification, plant and equipment, and end-specifications.

Manufacture: Stages and Procedures

BOVINE HIDES: CHROME TANNAGE: FOOTWEAR LEATHERS.

Schematic 1(b) continued

"Overview" ©R.P.Daniels

Stage	Procedures	
Stage 3 Removal of water and Reconfiguration Into a flattened form with specific properties	Samm/set	- Preparation for drying.
	v	
	+/- Side	- (very occasional practice)
	v	
	+/- wet stretch/stake	- Extension and relaxation of structure. May be used before drying, and within some drying operations.
	v	
	Vacuum dry in conjunction with suspension dry (tension free) (or) Toggle dry (High strain and tension) (or) Dehumidification dry (light tension)	- Many permutations both In preparation and drying. Heavy compression, and high strain / tensions in drying develop strong increases in firmness. Significant influences in properties of final leather.
	v	
	+/- Conditioning	- Moisture content adjust. May avoid if drying via relative humidity control.
	v	
	Vibration staking (may be multiple)	- Soften to specification.
	v	
	Second time drying. (tension free)	- Lowering of water content from staking requirement.
	v	
	+/- Milling	- Soften/texture if required.
	v	
	Crust inspection (assessment/evaluation)	- Quality, technical and aesthetic to specification
	v	
Stage 4 Application of finish + Structural amendment	**Finishing operations** (multi-permutations) To specification/end-use	- Formation of new hybrid grain/finish structure. Grain wetting/drying + compression under heat and pressure. Changes in appearance, structure and properties.

Details set down for broad information only. Variations in procedures required according to materials classification, plant and equipment, and end-specifications.

Panel 1 *"Overview" © R.P.Daniels*

Characteristics of different tannages

Tannage	Properties of dried leathers (tanned only)	Shrinkage temperature (saturated) and Charge	Dyeing, retanning and fatliquoring. (anionic products)	Properties of final leathers and End uses
Chrome	Blue-green colour. Hard and thin.	100C. Cationic	Good dye properties. High uptake of retanning agents and fatliquors.	Very versatile. Very soft to firm. Footwear, auto, furniture, bags, leather goods etc.
Glutaraldehyde	Light yellow brown colour. Soft to medium. Thin with poor retention of shape unless heavily supported by syntans/resins.	Approx 75C. Anionic	Poor dye properties. Poor uptake of retanning agents and fatliquors.	Very soft to firm. Good aging properties. Auto use – mouldings and seats if heavily retanned. Footwear, upholstery.
Other tannages (Many options)	White to pastel colours range. Moderately soft / firm handle.	75C – 85C. Anionic	Poor dye properties. In general, similar uptake of retanning agents / fatliquors as "Glutaraldehyde".	Soft to firm. Many variations, with mainly glutaraldehyde – type properties.
Light vegetable	Cream to light brown colour. Moderately soft.	Approx. 85C. Anionic	Poor dye properties. Low requirement for retanning agents and fatliquors.	Soft to firm with good shape retention. Well filled leather suited for shoe linings and leather goods. Anti-bacterial properties and warm handle.
Heavy vegetable	Light to red-brown. Firm, with dense structure.	Approx. 85C. Anionic	Dyeing and retannage mainly not required.	Offers excellent shape retention. Suited for soling, harness, belts, moulding and carving.

Note:

- Information for general guidance only.

Panel 2 *"Overview" ©P. Evans*

Finish variations

Structure	Category		
Full grain	Aniline	Semi-aniline	Pigmented
Corrected	Aniline	Semi-aniline	Pigmented