

MODERN COW LEATHER PROCESSING – Version 1.1 – May 12, 222

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MODERN COW LEATHER PROCESSING

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HALO TOUCH

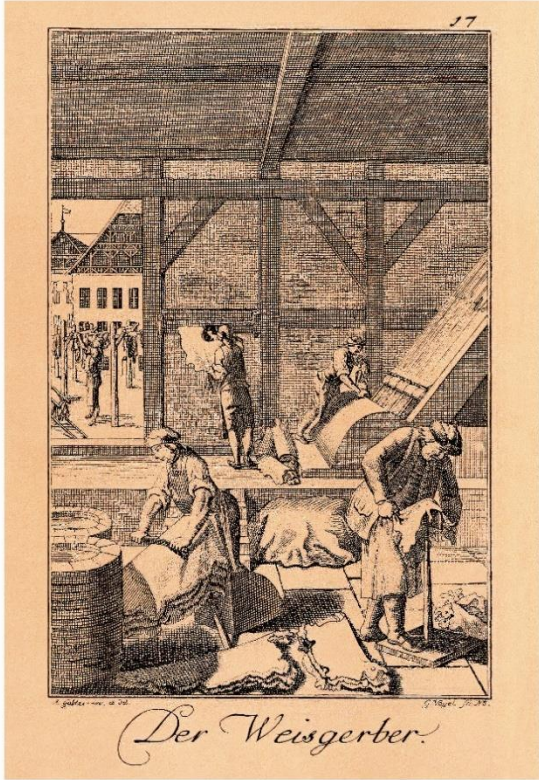
INTRODUCTION

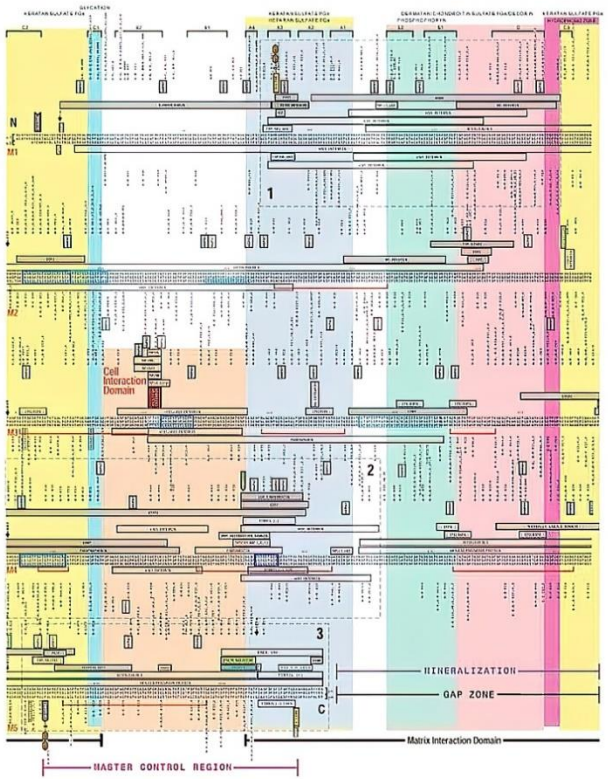
Since **pre-historic times** animal skins have been used for **protection against the elements.** The primitive preservation process was through smoking and drying. Later, vegetable extracts were used to **create the first leathers.**

Leather making became one of the oldest known industries. The earliest tanning recipe was created **around 700 BC.** C**hemistry** and tanning **processes have continued to evolve down through the generations.**



SCIENCE AND ART





Working with hides and skins started as a craft. The **biggest evolution in the industry came during the Roman Empire** when vegetable leathers were standardized. Later, chemistry and biochemistry were applied to the processes, and **leathers obtained outstanding characteristics that were considered almost magic.** During the Renaissance, art was involved in **leathermaking through the application of colors and shapes.**

Biochemistry defined the composition and structure of the hides. Chemistry brought the performance. Physics brought the processes. **Engineering** brought the **automation and process controls.** Today, 21st-century leathermaking is still a powerful blend of art, science and technology as well as **safe and compliant.**

TODAY SUSTAINABLE LEATHER IS PRODUCED
for performance, fashion and luxury

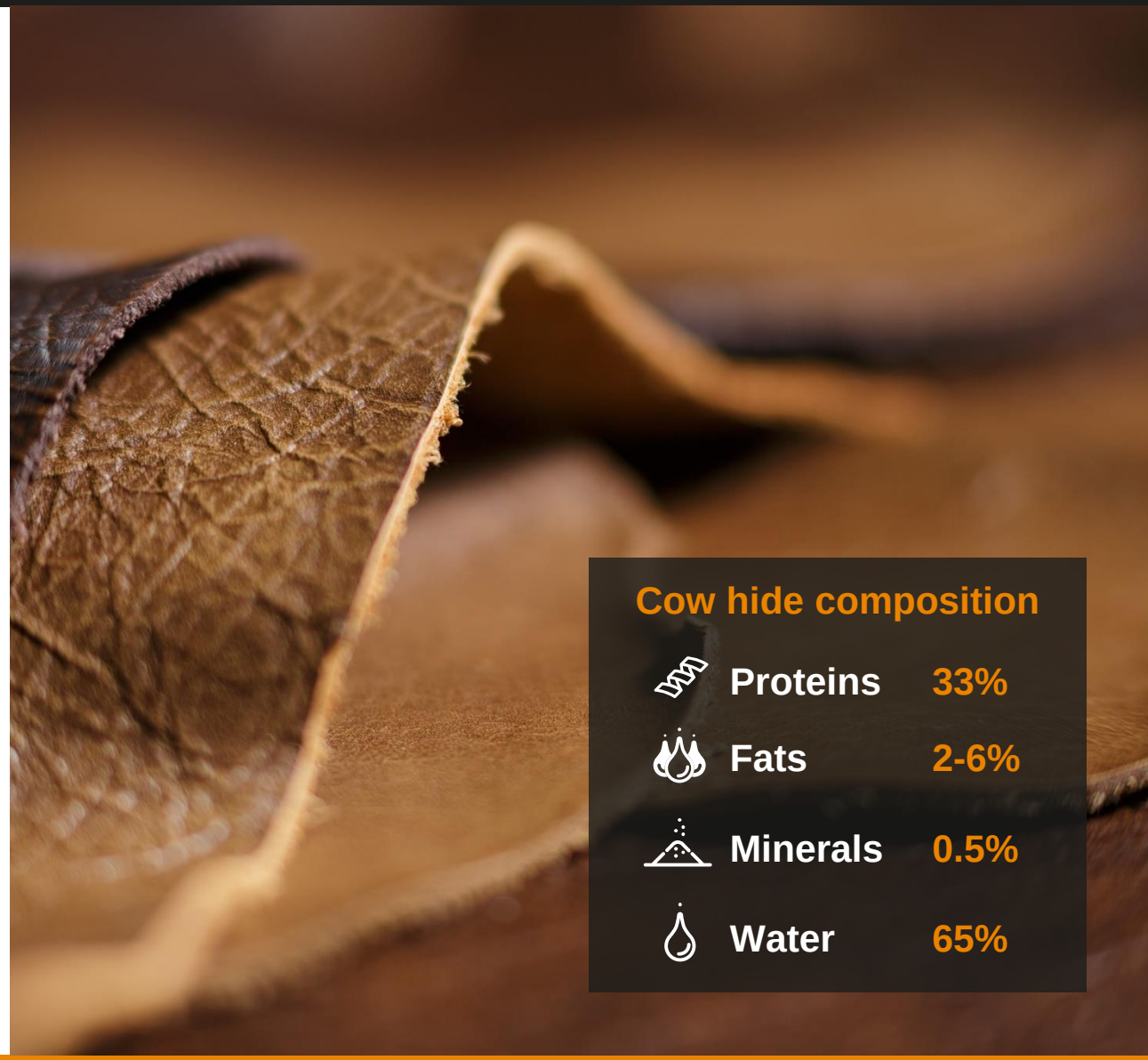
Hides are a no-waste by-product of the food industry. The leather industry uses the hides and skins produced by the meat industry, and only exists because of the meat industry.

No meat = no leather

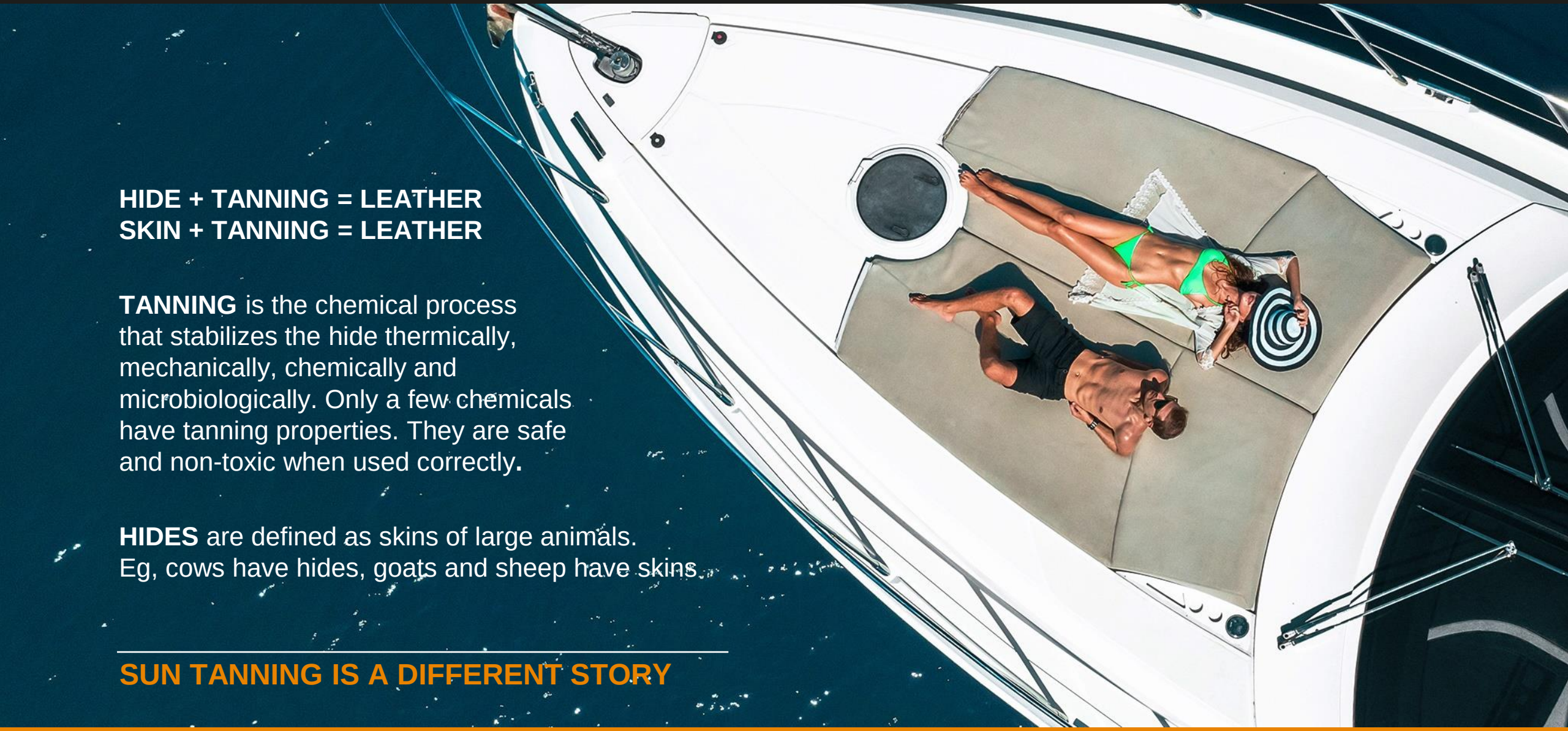
Hides are very complex organs composed mostly of proteins, fats, water and minerals.

The main proteins in a hide are:

- **Collagen** – to be turned into leather
- **Keratins** – hair and epidermis, that are removed
- **Globular proteins** – removed



DIFFERENCES BETWEEN
hide, skin and leather



HIDE + TANNING = LEATHER
SKIN + TANNING = LEATHER

TANNING is the chemical process that stabilizes the hide thermically, mechanically, chemically and microbiologically. Only a few chemicals have tanning properties. They are safe and non-toxic when used correctly**.**

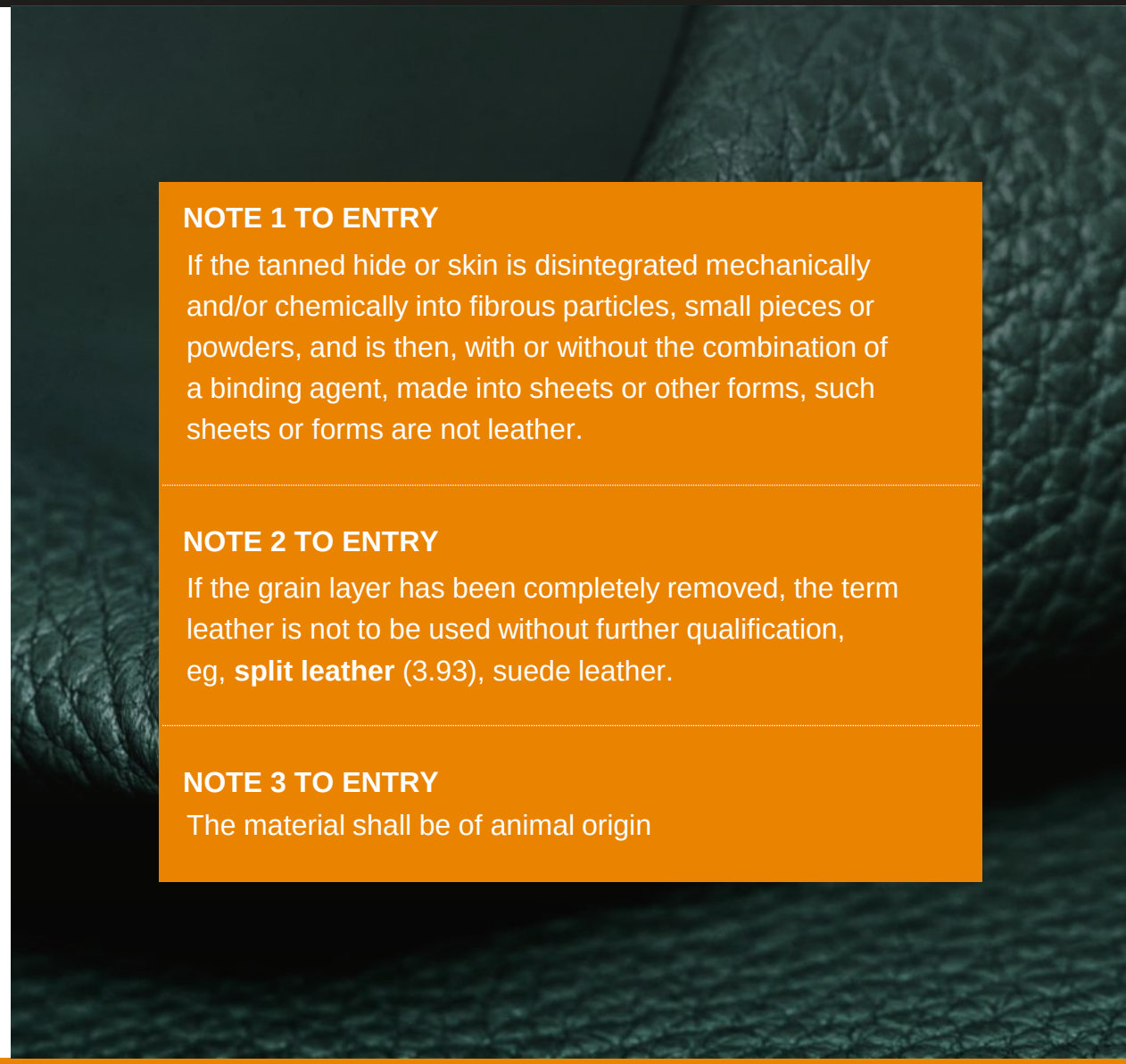
HIDES are defined as skins of large animals.
Eg, cows have hides, goats and sheep have skins.

SUN TANNING IS A DIFFERENT STORY

DEFINING LEATHER

ISO STANDARD 15115:2019
(International Organization for Standardization)

<material> hide (3.48) or skin (3.88) with its **original fibrous structure** more or less intact, tanned to be imputrescible, where the hair or wool may or may not have been removed, whether or not hide (3.48) or skin (3.88) has been **split into layers or segmented** either before or after tanning (3.97) and where any surface layer, however applied, **is not thicker than 0.15 mm**



NOTE 1 TO ENTRY

If the tanned hide or skin is disintegrated mechanically and/or chemically into fibrous particles, small pieces or powders, and is then, with or without the combination of a binding agent, made into sheets or other forms, such sheets or forms are not leather.

NOTE 2 TO ENTRY

If the grain layer has been completely removed, the term leather is not to be used without further qualification, eg, **split leather** (3.93), suede leather.

NOTE 3 TO ENTRY

The material shall be of animal origin

FROM HIDE TO LEATHER



Here is a cross section of salted hide (bottom) that shows the **fat on the lower layer**, the **hide matrix in the middle** and the **hair on top layer** (this is the grain side).

After processing to remove the hair and the lower layer we have a thick piece of hide. The color is light gray and has a rubbery feel.

The hide can be tanned with chromium, synthetic tanning agents or vegetable extracts. In our illustration we see the full thickness of the hide compared to the size of a one cent coin.

COW HIDES IN NUMBERS



The total number of cow hides available for tanning is about 270 million each year

A typical fleshed cow hide weighs 25 kg (55 lb.) and has an area of 4.5 m^2 or 50 ft^2

NOT ALL COW HIDES ARE THE SAME

There are big differences between cow hides. Here are the main variables:

AGE

In most countries, beef steers, heifers and cows are matured to around 24 months. Milk cows and bulls can be a good deal older. The older animals may have lower quality hides due to parasites, scratches, manure damage, growth marks and wrinkles.

BREEDS

Breed determines the size, thickness, fiber structure, shape and hair type of the hide.

SEX

Better quality hides in commercial quantities are usually obtained from steers and heifers. In general, bulls produce bigger and thicker hides. Certain European bulls have an excellent grain quality that's ideal for automotive and residential upholstery. Cows usually have thinner hides, with more spread and often have empty bellies and pocketing.

FEED

Confined animals (feed yards or lots) may have less new damage but, during winter, manure can accumulate on the hide and lead to grain damage. Grass-fed animals in open fields or savanna are more prone to parasitic damage and subsequent scratch damage.

CLIMATE CONDITIONS

Dictate which breeds are suitable for a specific location. Some breeds can tolerate severe winters, others tropical or hot climates. Geographical and climate conditions determine the best breed for locations that are suitable for meat production, not for the quality of leather they produce.

BRANDS

Animal control by RFID (Radio Frequency Identification Device) is growing in use as it also works as a powerful traceability tool. Fire or freezing brands are still used (by law in some locations); these brands severely reduce the quality of a hide, particularly when multi-branding is used.

HIDE CHARACTERISTICS
of the major producing countries

COUNTRY	VOLUME MILLIONS	ANIMAL FEED SYSTEM	GRADES	MAIN BREEDS	USES	OTHER	HIDE PRESERVATION METHODS
Brazil	38	Mostly grass-fed (80%)	▪ 5% full grain ▪ 70% corrected grain ▪ 20% low grades	Zebu Brahma	Upholstery, shoe uppers, leather goods and automotive	▪ Damage by ticks, wire and grubs ▪ Hides are thin, have a hump ▪ Branded	▪ Short term preservation and salting
USA	34	Grass-fed, grain finished	▪ Full grain 30%	Various; Angus and Hereford breeds	All uses	▪ Largest global supplier of hides with consistent thickness, size and seasonal quality ▪ Branded ▪ Winter hides can have manure and frost damage	▪ Fresh processing of hides ▪ 65% brine cured for export
Europe	26	Mostly Grass-fed	▪ Mostly full grain	Various	All uses	▪ Wide range of sizes and qualities ▪ Calf and veal for premium leathers ▪ Heavy bulls of top and medium quality for upholstery ▪ Steer, heifers and beef cows of good quality	▪ Fresh and salted
China	25	Grass-fed	▪ Mostly full grain	Various	Shoes and leather goods	▪ Hides are sold by area ▪ Production concentrated on third and fourth quarters	▪ Salted
Argentina	14	Grass-fed	▪ 90% full grain ▪ 10% corrected grain	European Angus and Angus cross-bred	All uses	▪ Hides are smaller and thick, making good quality full grain and good suede ▪ Spring hides may have parasites	▪ Salted and fresh
Mexico	7	Mostly grass and feed lots	▪ 20% full grain ▪ 40% corrected grain/auto ▪ 40% low grades	Various	Automotive upholstery, shoes, leather goods	▪ North has better selections ▪ Damage by ticks and parasites ▪ Broad types of hides, variation in size and weight. Branded by law	▪ Fresh processing of hides and salting
Australia	7	Grass and grain-fed	▪ Mostly corrected grain	Various	Upholstery, shoes, corrected grain	▪ 55% is produced in Queensland – ticks an issue ▪ NSW/Victoria produce better quality but have flies in the summer and lice/mites in the winter	▪ Fresh and salted

UNITED STATES COW HIDE CLASSIFICATION

GUIDE TO PACKER HIDE SELECTIONS WITH ESTIMATED WEIGHTS			NET WEIGHT RANGE POUNDS (lb.) CURED	
Selection	**Type**	**Description**		**Trimmed & Fleshed**
Extra Heavy Native	Steers and heifers	Free of brands		64 up
Heavy Native				47 up
Extra Heavy Butt-branded	Steers and heifers	Branded one or more times back of break in flank		64 up
Butt Branded				47 up
Extra Heavy Colorado (Side branded)	Steers and heifers	Branded one or more times forward of break in flank		64 up
Colorado Branded				47 up
Extra Heavy Branded	Steers and heifers	Branded one or more times		67 up
Branded				47 up
Extra Heavy Texas	Steers and heifers	Texas Panhandle Area origin		64 up
Heavy Texas				47 up
Native – Light	Steers and heifers	Free of brands		55 down
Texas – Light	Steers and heifers	Mix of Texas		55 down
Branded – Light	Steers and heifers	Branded one or more times		55 down
Heavy Native Cows (Dairy)	Milk breed cows	Free of brands		45 up
Native Cows (Dairy) Light				45 down
Heavy Native Cows (Beef)	Beef breed cows	Free of brands		45 up
Native Cows (Beef) Light				45 down
Heavy Branded Cows (Beef)	Beef breed cows	Branded one or more times		45 up
Branded Cows Light (Beef)				45 down
Selection	**Type**	**Description**	**Curved Conventional**	
Native Bull	Males	Free of brands	85 up	
Branded Bull	Males	Branded one or more times	85 up	

UNITED STATES
Wet blue classification

In the United States, wet blue is sold by surface area (ft²) or weight in pounds (lb) (considering 50-60% moisture). Price varies by class and type.

Class name	Characteristics	Hide type
Native	No brands	Heifer, steer or jumbo
Butt Branded	Only one brand below the center of the leather	Heifer, steer or jumbo
Colorado	Multiple brands or one brand above the center line	Heifer, steer or jumbo
M Cattle	Mexican breeds raised in the US – distinctive mark on the right butt cheek	Mix of heifer, steer and jumbo
Special	Over a third of the leather is defective through natural or process defects	Mix of heifer, steer and jumbo

Note: wet blue types made in the USA do not include cow leather

OTHER CLASSES

Heifer (best quality)**: HNH** (Heavy Native Heifer) **> BBH** (Butt Branded Heifer) **> BH** (Branded Heifer)

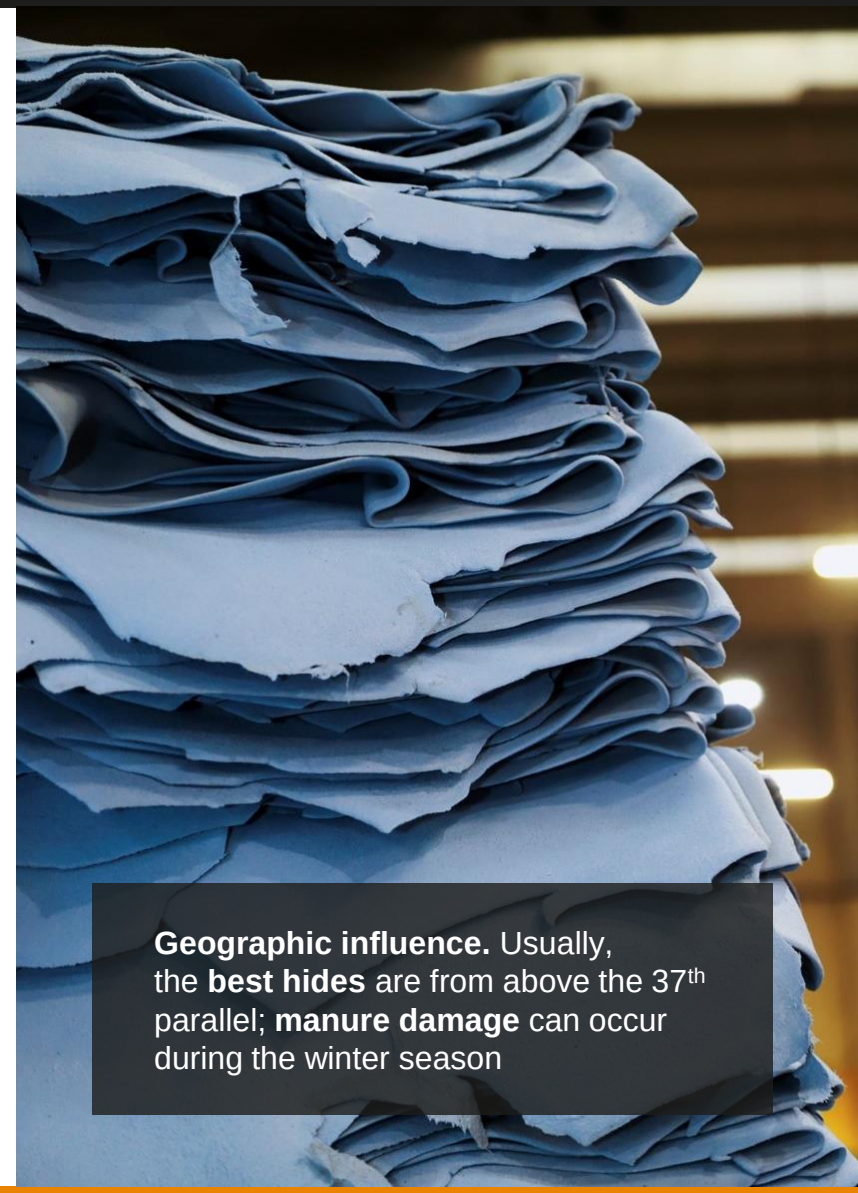
Steer (best quality)**: HNS** (Heavy Native Steer) **> BBS** (Butt Branded Steer) **> BS** (Branded Steer) **> HTS** (Heavy Texas Steer)

HIDE TYPE WEIGHTS

Heifer: fresh hide weight up to 58 lb. (26 kg)

Steer: fresh hide weight between 59 and 92 lb. (27 to 42 kg)

Jumbo: fresh hide weight above 93 lb. (42 kg)



Geographic influence. Usually, the **best hides** are from above the 37th parallel; **manure damage** can occur during the winter season

BRAZIL
Wet blue classification

This is the typical wet blue grading, ranging from premium to lower grade quality:

TR I **Extra Heavy** – Average area 52-56 ft², Average weight 28-30 kg

Leathers come from 100% Zebu bulls. They are apt for heavy finished leathers, shoe leathers, waxy leathers, belts, horse saddlery and upholstery. Better grades can have lighter finishes.

TR I **Standard** – Average area 48-52 ft², Average weight 24-26 kg

This is the main type of leather from the central part of Brazil, which has the largest herds and produces better beef cattle. Leathers can have a wide number of applications: shoes, upholstery, automotive and leather goods.

TR II – Average area 46-48 ft², Average weight 22-24 kg

TR III – Average area 46-48 ft², Average weight 21-23 kg

TR IV – Average area 46-48 ft², Average weight 20-22 kg

Leathers for shoes, automotive and price-conscious upholstery, and some types of leather goods. As the grading reduces so the amount of finishing increases, to hide the imperfections.

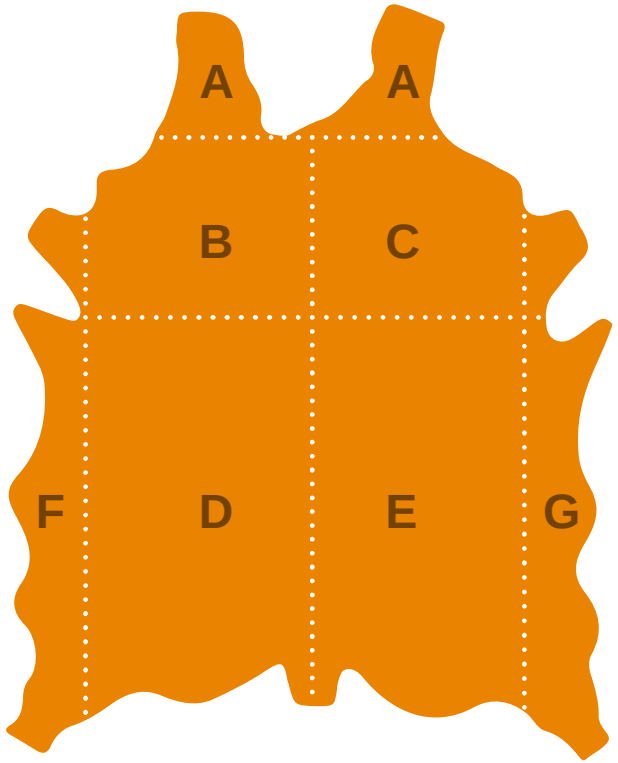
TR V **Economic** – Average area 46-48 ft², Average weight 18-20 kg

Leathers for low grade upholstery and shoes with a heavy finish eg, safety shoes.

Reject – Average area 46-48 ft², Average weight 18-20 kg

Leathers used for shoes with a heavy finish, such as safety shoes and safety items.

PARTS OF A HIDE AND TYPICAL DEFECTS



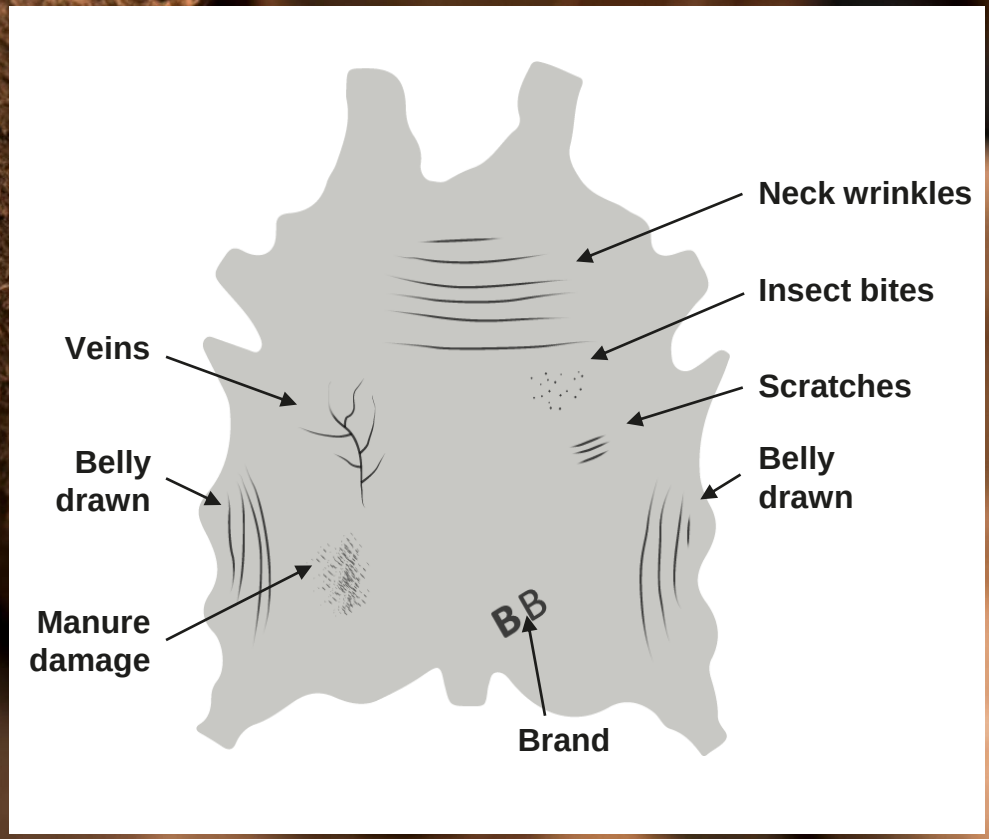
Belly: F and G

Bend: D and E

Croupon: D+E

Side: A,B,D and A,C,E

Shoulder: B+C



TYPICAL NATURAL DEFECTS FOUND ON LEATHER

BRANDS





SCRATCHES



VEINS

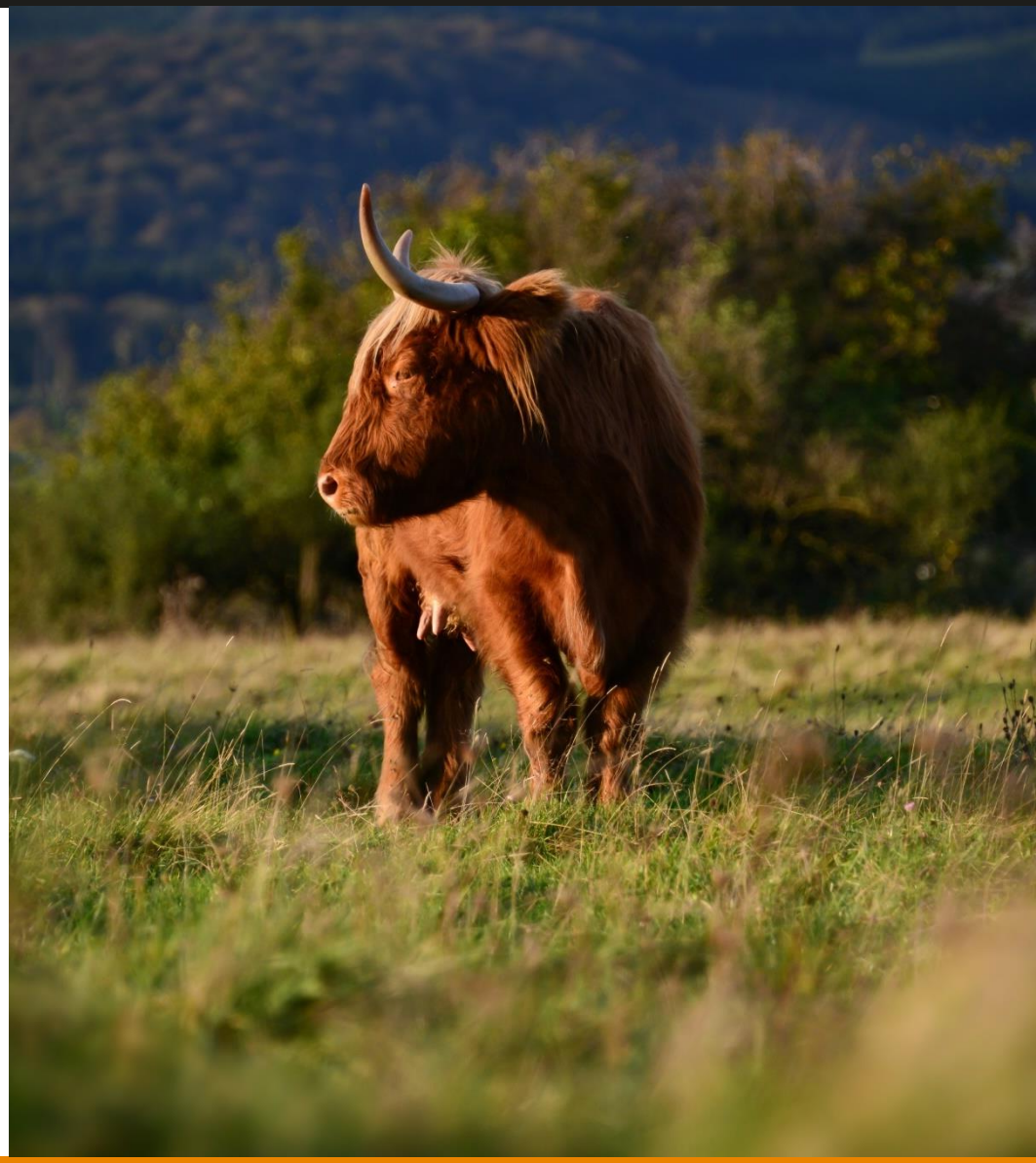


WRINKLES



PARASITES AND INSECT BITES





PRESERVING AND SHIPPING HIDES

Hides can be processed fresh after removal from the animal, or they can be preserved. Globally, about **30% of hides are processed fresh; 70% of them are preserved by salting** (or brine curing) then processed locally or overseas. **Salted hides** have solid salt added **to dehydrate and saturate the hide.** In brine curing the hides are immersed in a salt solution **for 24 hours to saturate the hides with brine.**

Salting is the **most efficient and cost-effective way of** preserving hides for up to one year. The hides are put on pallets with **about 40 hides each. A container can hold around 600 hides (USA).**



Increasingly, the global trend is to avoid salting by processing fresh hides either with or without refrigeration

COW HIDE CROSS SECTION



Here is a typical cross section of an American cow hide stained with Hæmatoxylin. It shows the **different thicknesses and lengths of the hairs.** The area shown is the **grain area**, which is defined as being from the **surface (epidermis) to the bottom of the hair follicles.** This is the most valuable area of the leather.

A LOOK AT LEATHER'S STRUCTURE

LEATHER GRAIN

Area from the surface to the bottom of the hair follicle. Fibers are fine and elastic on the top and get bigger and thicker going down. To get the required thickness, grain leathers usually contain part of the split

LEATHER SPLIT

Area from the bottom of the hair follicle to the flesh side. Fibers are closely interwoven. Closer to the bottom, fibers get finer and sit parallel to the flesh side



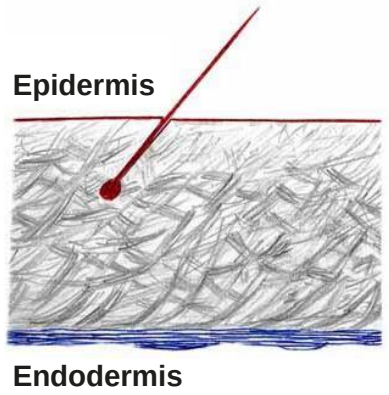
LEATHER TYPES

- full grain
- snuffed grain
- corrected grain
- nubuck

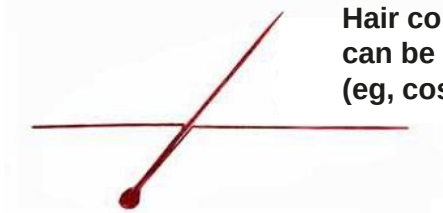
LEATHER TYPES

- splits
- suede
- PU splits

INDUSTRIAL COW HIDE BY-PRODUCTS



After hair removal



Hair consists of keratins and can be used for hydrolysates (eg, cosmetics) and industry



This is the dermis that will become leather. It can also be used to make collagen for feed, industry, cosmetics, medical and hundreds of other applications. Collagen doesn't have the same nutritional value as meat.

After fleshing



Fatty material and proteins used for industrial applications

Hides are trimmed to remove parts that cannot be used to make leather. **They are fleshed** to remove the endodermis before curing or after processing (liming). **After hair removal,** collagen, the central part of the hide (dermis), will be **transformed into leather.** Only a few cow hides are **tanned 'hair on'.**

WHAT IS A TANNERY?

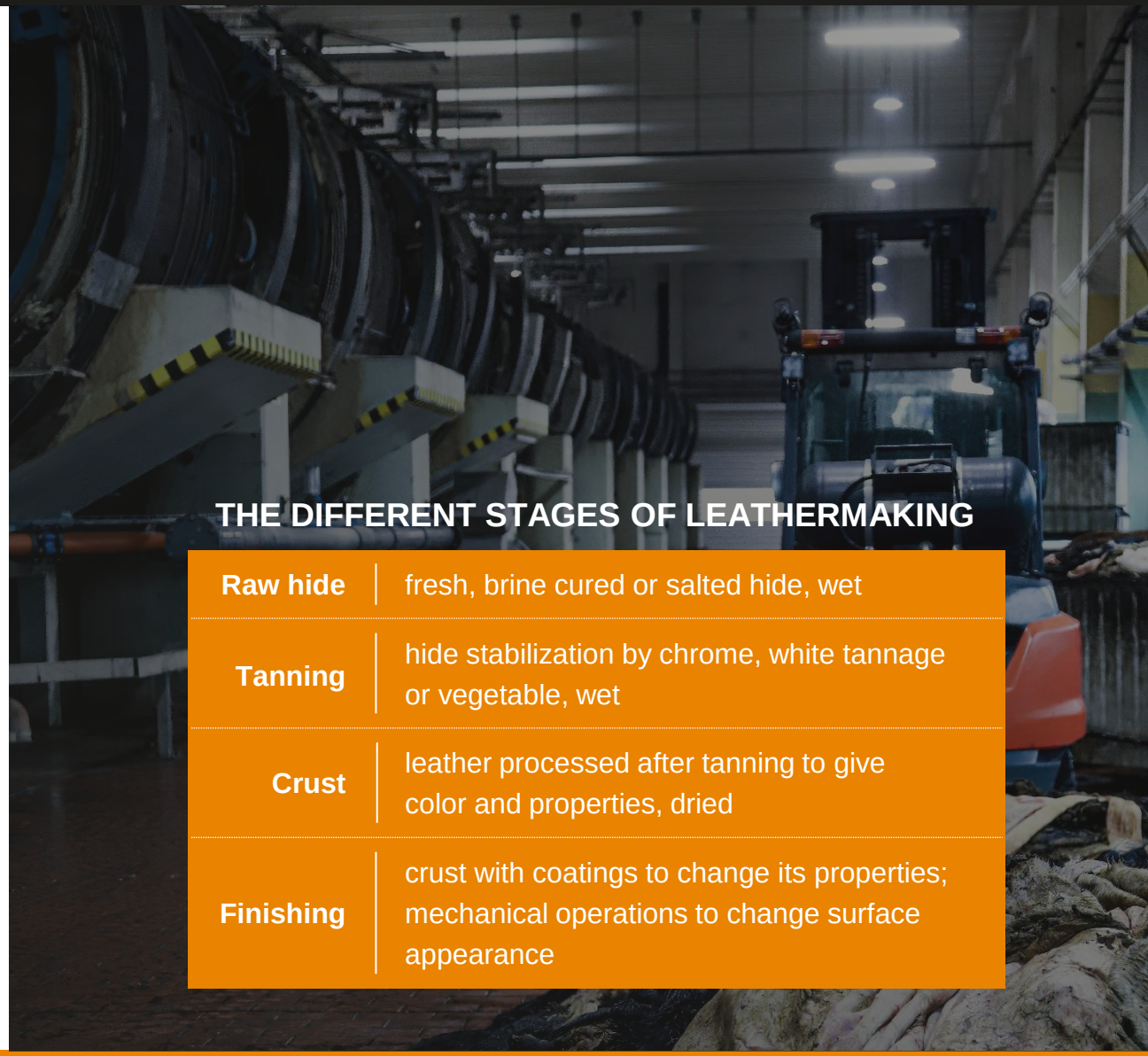
Tanneries are leather processing units that comprise chemical and mechanical processes alongside waste treatment.

Tanneries can be classified by size

- **small:** up to 500 hides/day
- **medium:** 500 to 2,000 hides/day
- **large:** more than 2,000 hides/day

Types of tannery

Complete	from raw to finishing
Tanning	from raw to tanning (also called blueing; can also be white tanning and vegetable)
Wet End	from tanned leather to crust (or to finishing)
Finishing	from crust to finishing



THE DIFFERENT STAGES OF LEATHERMAKING

Raw hide	fresh, brine cured or salted hide, wet
Tanning	hide stabilization by chrome, white tannage or vegetable, wet
Crust	leather processed after tanning to give color and properties, dried
Finishing	crust with coatings to change its properties; mechanical operations to change surface appearance

TYPE OF WORK CARRIED OUT IN A TANNERY

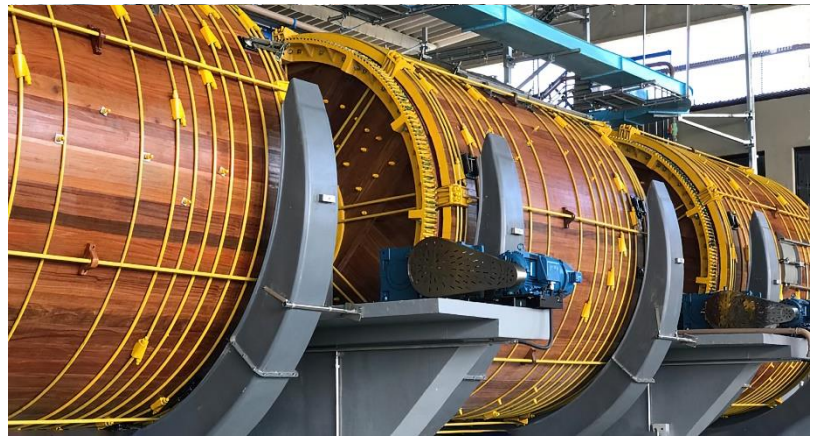
- **Leather processing –** conversion of hides into leather, grading, packaging and shipping
- **Product development –** new colors and leathers; fashion items and new products
- **Process optimization –** time, water, energy, chemicals and waste reduction
- **Environmental control** for liquid, solids, air
- **Safety of** equipment and of workers
- **Chemical hygiene plan**, proper chemical handling, including safety audits
- Physical and chemical **testing of leathers**
- **Maintenance of the equipment –** keeping it safe and functional
- **Production flow management –** optimization of time and resources
- **Quality control** of incoming raw materials, processes and finished products



MAIN PROCESSING EQUIPMENT

Each stage of the process that takes raw hide to crust is **done in batches. Wood and polypropylene drums** offer the mechanical action needed for the chemicals to react with the hides or leathers. **Mixers** (‘Canbar®’) **can be used in the beamhouse**

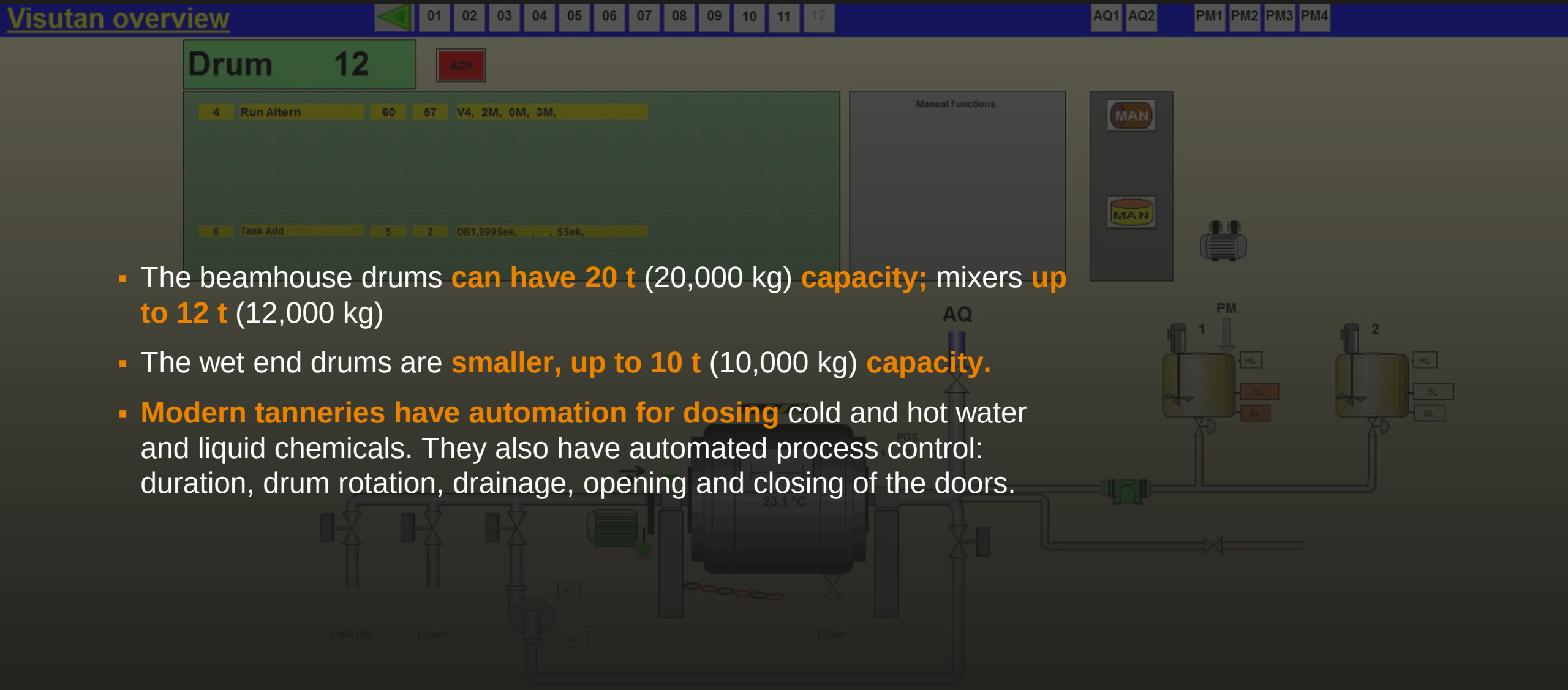
DRUMS



MIXER

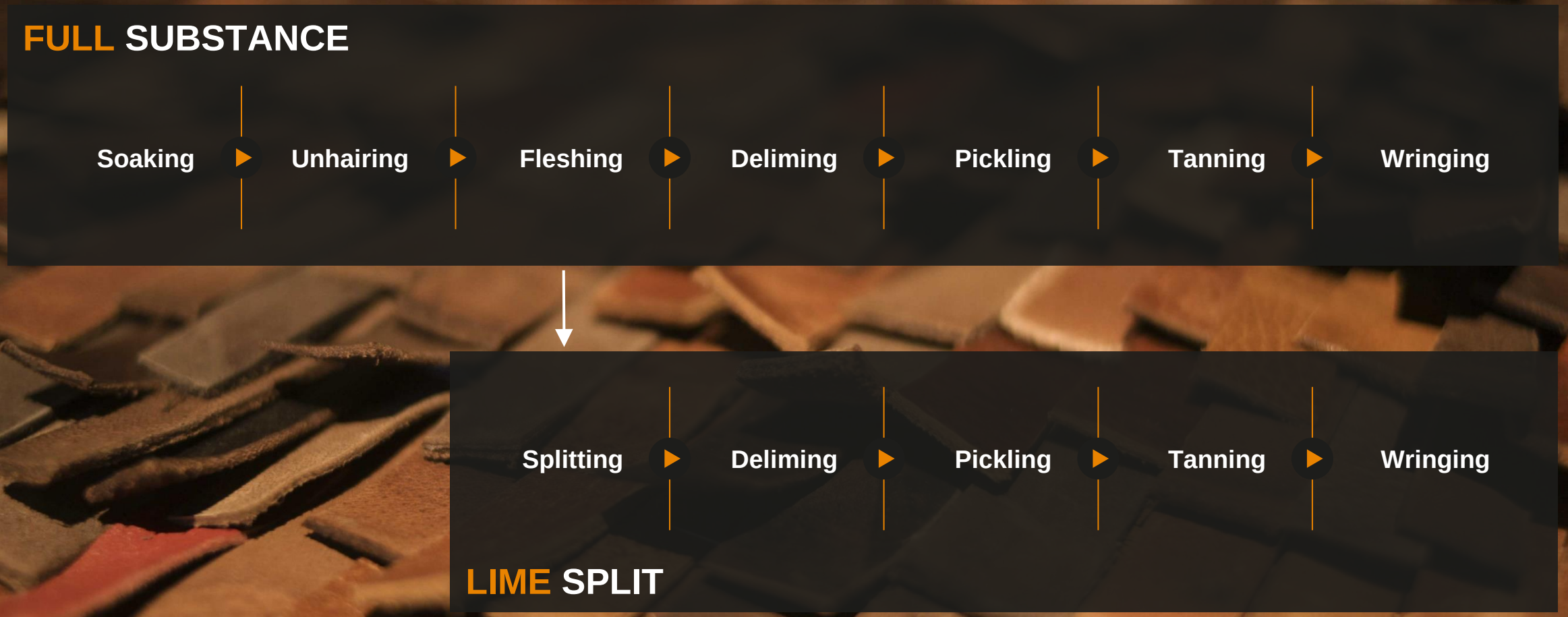


MAIN PROCESSING EQUIPMENT
– continued



- The beamhouse drums **can have 20 t** (20,000 kg) **capacity;** mixers **up to 12 t** (12,000 kg)
- The wet end drums are **smaller, up to 10 t** (10,000 kg) **capacity.**
- **Modern tanneries have automation for dosing** cold and hot water and liquid chemicals. They also have automated process control: duration, drum rotation, drainage, opening and closing of the doors.

TYPICAL BEAMHOUSE (RAW TO TANNING) DIAGRAM



TYPICAL BEAMHOUSE (RAW TO TANNING) PROCESS

Soaking	▪ Hides are cleaned to remove dirt, some fatty materials and soluble proteins
Unhairing	▪ This procedure removes the hair and epidermis. Also called ‘Unhairing and Liming’ because lime is used
Fleshing	▪ Mechanical process to remove the endodermis and fat from the inner part of the hide. Mostly fully automated
Deliming	▪ Chemical process to remove the alkalinity and lime. Enzymes are added for softening (bating)
Pickling	▪ Salt, organic salts and acids are added to prepare the hide for tanning
Tanning	▪ Chrome, vegetable and synthetic tanning agents (eg, glutaraldehyde) are added to convert the hide to leather
Set out	▪ Automated mechanical process that removes water and adjusts leather to 50% - 60% moisture

BEAMHOUSE MACHINERY



FLESHING MACHINE

This removes the endodermis and fatty material of the hide, preparing it for the next steps.



SPLITTING MACHINE

Equipment used to split the hide into a top part (grain side) and a bottom part (flesh split). This step is either carried out after fleshing (as in the photo), or after tanning.

TYPICAL CHEMICALS USED IN THE BEAMHOUSE (RAW TO TANNING) PROCESS

Soaking	▪ Soda ash, magnesium oxide, enzymes, bactericides, wetting agents and emulsifiers
Unhairing	▪ Sodium sulfide, sodium sulfhydrate, lime, enzymes, degreasers, emulsifiers, penetrants
Fleshing	▪ Mechanical process only
Deliming	▪ Ammonium sulfate or chloride, organic acids, carbon dioxide, acid salts, degreasers and enzymes
Pickling	▪ Common salt, organic acids, sulfuric acid
Tanning	▪ Mostly chrome (III) sulfate, tannins, syntans and glutaraldehyde. Fungicides are added here to protect leather against mold
Set out	▪ Mechanical process to adjust leather moisture to 50% - 60%

MAIN TYPES OF TANNAGE AND WHAT THEY DO



Tannage is essential for stabilizing the hides. After the first and main tannage the leathers can then be re-tanned with other chemicals **to change their properties.** Chrome leathers are commonly **re-tanned with vegetable extracts**

VEGETABLE

This is the **oldest method of tanning,** dating back more than 2000 years. It uses **only natural plant extracts.** These leathers are **light brown in color** and dense, making them suitable for shoe uppers and soles, belts, handbags, watch bands, and leather goods. **They keep their shape very well** and age beautifully.

CHROME

Was developed in the 1900s. **The process uses chrome (III) salts** and produces leathers of a blue color that **can be dyed to a range of other colors. Produces soft to medium temper leathers**. Can be used for a variety of articles from garments, upholstery, shoes, handbags, to other leather goods. It is the **most common tannage,** accounting for about 80% of leather produced. The intermediate product of the leather **is called 'wet blue'.**

WHITE (chrome-free)

Most white tannage is made using a **synthetic product called glutaraldehyde**. It produces a leather that has a **light-yellow coloration.** This leather **needs to be processed further with other chemicals** like vegetable extracts, syntans, acrylics to give a **final level of finish and performance.**

CHROME TANNAGE

Chrome tannage **uses mostly** chrome (III) sulfate – the **worldwide industry standard** is a soluble green powder that contains 26% Cr_2O_3. Leather made with chrome has a distinct blue color and it **is called ‘wet blue’ during the wet stage**. Wet blue leathers can be packed wet and **stored for long periods of time, up to six months**. It is a widely traded valuable global commodity. A container can hold about 800 wet blue leathers (USA).

Chrome leathers **need to be stored wet**, at about 60% moisture. If it dries out it cannot be re-wetted for successful use. **Storage is important** to keep the leathers at a uniform level of moisture to **avoid staining and a dried-out surface** that will have different properties.

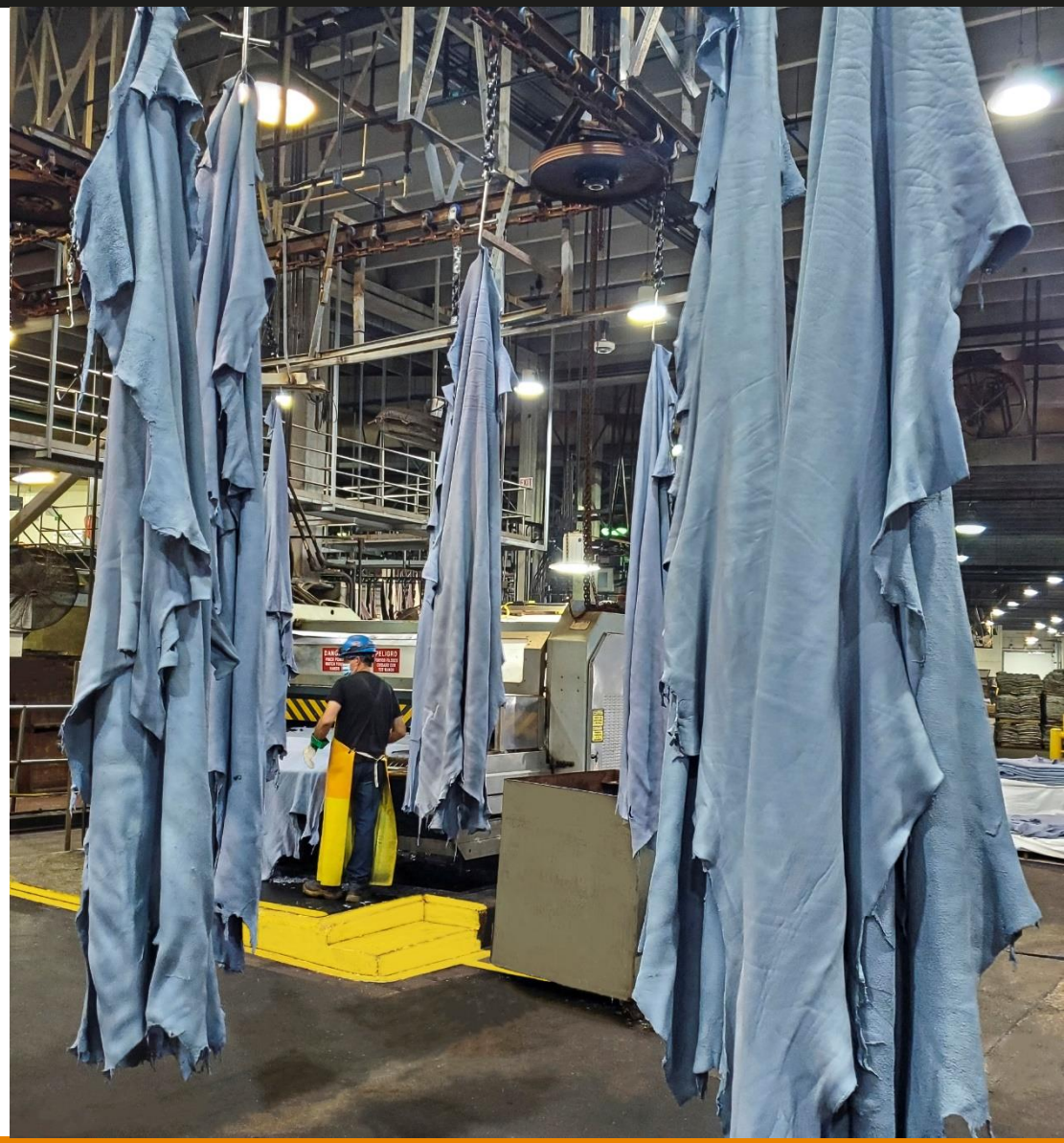


CHROME TANNAGE: STEP BY STEP

After liming, hides (full thickness or lime split) **are treated with chemicals** to remove the lime (deliming process), then **treated for six to eight hours with a salt + acid solution** called pickle to prepare them for tannage. Usually 6% chrome (III) sulfate is then **added for the tannage that takes eight to 12 hours.** An alkaline product is added during tanning to **increase the pH to about 3.8.** This increase in pH along with process temperature increase (up to 48°C) **will complete the tanning reaction**, optimizing the chrome fixation and reducing the **amount of chrome in the effluent.** After tanning, the chrome solution is usually **recycled to minimize waste.** The total tanning process takes 20 to 24 hours. The chrome tannage itself is **relatively simple;** the challenge is to be **uniform from batch to batch.**

When the tanning process is complete, a few pieces of leather are **removed from the batch** and put in boiling water for three minutes – **the shrinkage temperature test** that will determine if the tannage has been completed correctly. The leather should not shrink **more than 5%.** The pH is usually **between 3.6 and 3.8;** the color remains blue.

When the tanning is complete, the wet blue is dumped from the drum or mixer and **put in boxes or on a chain** that will **bring it directly to the wringer.** The wringer is a press felt machine that will **squeeze the excess water** out of the wet blue, leaving it with about 60% moisture. The leather will be flat and light blue in color, **ready for further processing or packaging.**



WET BLUE LEATHER CHARACTERISTICS



- Can be made **with lime split hides or full thickness hides**
- Can be **split after wet blue.** Grain side and split can be **sold separated**
- Can be **sold by piece** (based on type) **or by area** (m^2 or ft^2)
- It is graded after production. See our section on grading
- Sold as a **whole piece or as sides** (halves)
- **Downgraded** by natural defects, barbed wire cuts, wrinkles, fine hair, color, being misshapen, machine damage, grain damage, pigmentation
- Leather needs to be **treated with fungicide** to avoid mold growth that **will cause staining**
- **Proper packaging and storage conditions** are important to maintain the quality of the product to **avoid stains and drying**
- Typical sizes are **from 3.5 m^2 to 5 m^2 (38 ft^2 to 54 ft^2)**

VEGETABLE TANNAGE – THE ORIGINAL PROCESS

Vegetable tannage is the oldest commercial method of making leather.
Vegetable-tanned leather items have been discovered that date back 4,000 years.
Only natural plant-derived materials, extracts called 'tannins', are used for the tannage: roots, leaves, fruits, bark, wood and seeds.

The chemical components from the plant extracts are **called 'tannins'**, **natural complex chemicals** whose main function is **plant protection**. Common black tea *(Camellia sinensis)* contains tannins too; if you **use enough, it can produce leather!**

Today the majority of vegetable tannins are **extracted from cultivated plants.**

Each tannin extract has **is own properties of color, reactivity, softness, fullness, penetration, etc,** and it is usual to use them in blends to **achieve the leather properties required.**

For **industrial production,** the plants are ground, and the tannins are **extracted by hot water at low pressure, concentrated and then converted into powder** (spray dried). Tara pods are **dried and ground only.** Factories are very modern and use raw materials from sustainable sources.

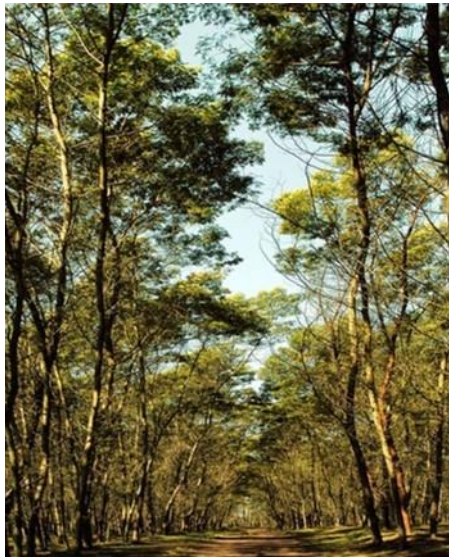
Typically, **the tannins react slowly with the hides** at a pH above 5. They are fixed to the hide at lower pHs of around 3.5.

For a full tannage, **about 30% of powdered tannin** (from quebracho, chestnut or wattle) is needed.

Tannins can be used as the main tanning and also the retanning agent, as we will discuss later in the Retanning slides.



MAIN SOURCES OF VEGETABLE EXTRACTS

	Chestnut *Castanea sativa*	**Mimosa** *Acacia mearnsii*	**Quebracho** *Schinopsis lorentzii*	**Tara** *Caesalpinia spinosa*
				
Plant part used	Wood	Bark	Wood	Pods
Countries	Italy (and across Europe)	Brazil, South Africa	Argentina, Bolivia, Paraguay	Peru and Bolivia

TRADITIONAL VEGETABLE TANNING IN TANKS

The oldest tanning system is these days mostly used for full thickness hides. The process consists of a **series of tanks that start with a low concentration of tannins, gradually increasing to higher concentrations.**

The hides are hung by the backbone to a rack (other parts of the hide can also be used for hanging them up, such as the croupon or shoulders). This **rack of hides is transferred daily** on a monorail **from one tank to the next**, which always has a higher tannin concentration. A tannery can have up to 100 tanks. Every day new hides are put in the first tanks, and leather is taken out of the last tanks. The **process from first to last tank can take between 20 to 30 days.**

Upon completion, the **leathers are washed and lubricated** with natural oils to increase their softness. If leathers are being made into shoe soles, then chemicals are added to increase density, water resistance and flexibility.

This system is still used in Italy and other parts of the world to produce the **finest leathers**. It's a process that needs daily adjustments of the tannin concentration and its pH, seemingly simple but requiring much expertise and analytical work.

Very little waste is generated by this process.



MODERN VEGETABLE TANNAGE



Polypropylene drums reduce metal stains, grain abrasion and improve process standardization

After unhairing and fleshing, sometimes splitting in full or sides, the hides are transferred to a wooden or polypropylene drum. **The first phase of this process is deliming to lower the pH and remove the lime, followed by pickling and conditioning,** that reduces the affinity of the tannins to the hide.

Tannage starts by creating a slow reaction between the tannins and the hide. This reaction allows the augmented penetration and fixation of the tannins. This process can take 24 hours for thin leathers and up to four days for sole leather. The **tanning needs to be slow** to avoid drastic reactions that can be detrimental to the finished quality.

While the tannins can be a mixture of quebracho, chestnut and wattle, other **auxiliary chemicals** such as syntans are usually used, too. This process is faster than tanks, and also yields good quality leathers.

Technology is evolving. Today, vegetable leathers can be very soft, lightweight and high performing

CHARACTERISTICS OF VEGETABLE-TANNED LEATHERS



The manufacture of vegetable-tanned leathers is more complex than for chrome leather

The **leathers produced using vegetables are usually heavier and firmer** than chrome leathers. The reaction of the vegetable extracts to the hide must be very well controlled in order to produce the proper penetration and fixation of the tannins. If the reaction of the tannins with the hide is too quick it will induce a shrunken effect in the hide, making resulting leathers non-uniform and with a pebble effect.

The tannins react with metals creating colored compounds, dyes, that are often impossible to remove. Tanneries must be well managed to avoid staining. **Drying vegetable leathers is also an art** and most of the time natural drying is used as force-dried leathers tend to break when folded. Vegetable leathers can be dyed in light colors after re-tan with syntans and are excellent used for shoes, boots, leather goods, embossing, engraving, bookbinding, saddlery and crafts.

WET WHITE TANNAGE
(chrome-free)

These are **alternative tannages to chrome and vegetable**. The main chemical used is glutaraldehyde; others are aluminum, zirconium, triazines, aluminum silicates and syntan-vegetable. **Metal-free leathers as defined in EN 15987** are required to have **less than 1000 ppm total metals** (Cr, Al, Ti, Zr and Fe). The main objective of this tannage is to achieve enough thermal stability to be able to shave the leather. It is not a true tannage, and the process **needs completing with a heavy re-tannage.** These leathers are **more expensive than chrome-tanned leathers.** In terms of waste and recycling this tannage has the advantage since there are no risks of waste converting into chrome (VI), while chrome is not a renewable material.

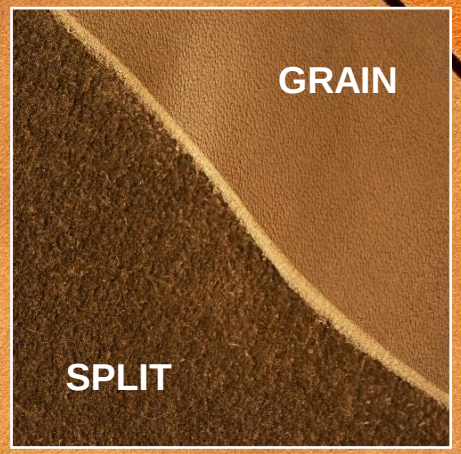
The main use of wet white is in the automotive industry, where leathers can be used in parts of the car that require thermal stability, mainly for dashboards and seats



DIFFERENT TANNAGE PROPERTIES

	CHROME	VEGETABLE	WET WHITE
Color of the intermediate	Blue	Light brown	Light yellow
Lightfastness	Excellent	Good/Fair	Good
Temper (softness)	Soft to medium	Medium to firm	Medium
Print retention	Poor	Excellent	Good
Versatility	Excellent	Good	Good
Waterproofness	Possible	Fair	Fair
Elongation	Good	Fair	Fair
Mechanical properties	Excellent	Excellent	Good
Soil resistance	Excellent	Good	Good
Washability	Yes	No	No

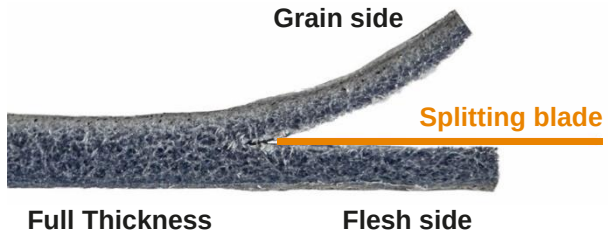
HOW DO WE MAKE LEATHER SO THIN?



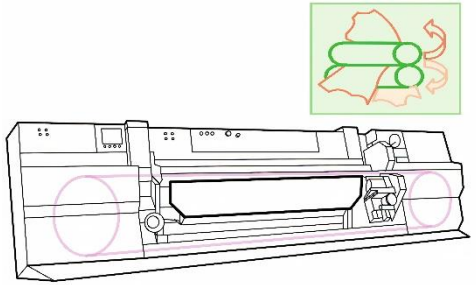
The hide (or leather) in the wet stage can be split horizontally after hair removal or tanning **by a large ‘splitting machine’** making two uniform slices.

The **top side** is called **‘grain side’** and the **bottom part** is called **‘split’ or ‘flesh side’**. The grain side is the most used, to make **full grain leathers**. The flesh side can be finished or used as **suede leather.**

Diagram of leather splitting



Splitting machine



MEASURING THICKNESS



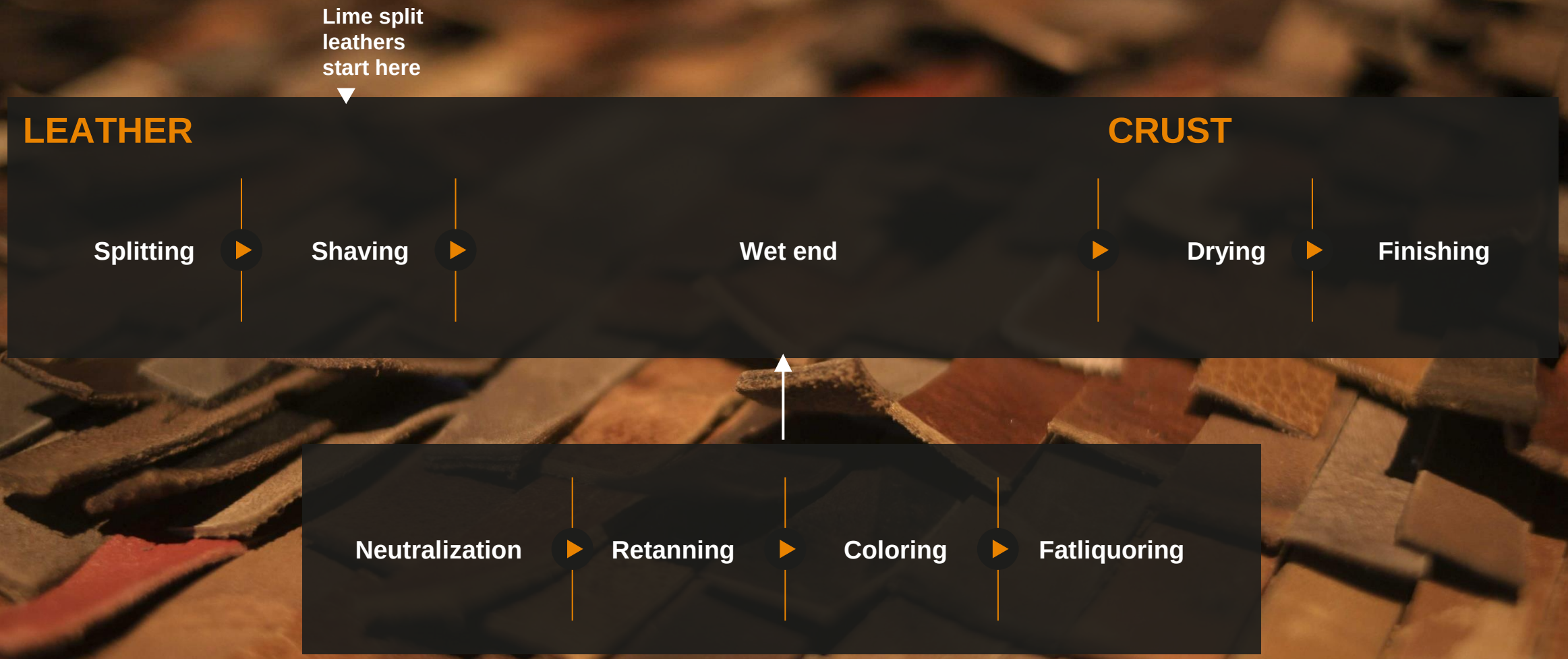
The millimeter (mm) is the most common thickness unit for leather.
Leather thicknesses usually have a range of 0.2 mm, for example:
1.1 to 1.3 mm, 1.2-1.4 mm; 1.4-1.6 mm; 1.6-1.8 mm; 1.8-2.0 mm, and so on.

The splitting process reduces the thickness. The shaving machine is used to uniformize leather thickness at the wet blue, vegetable or wet white (as in our photo) stage. Manual or automated thickness meters are used. They can be used as stand-alone instruments or be wireless or cloud-connected devices.

EXAMPLE OF OTHER LEATHER THICKNESS UNITS

LETTER	OUNCE	INCHES	MILLIMETERS
	1	1/64”	0.40
LL	2	1/32”	0.80
LM	3	3/64”	1.20
HM	4	1/16”	1.60
HH	5	5/64”	2.00
HHH	6	3/32”	2.40

TYPICAL FLOW DIAGRAM OF WET END



PROCESS FROM WET END TO FINISHING

Splitting	▪ Mechanical operation to slice the leather into grain and split parts
Shaving	▪ Mechanical operation to uniformize the thickness of the leather
Neutralization	▪ Chemical step to reduce the leather acidity in preparation for retanning
Retanning	▪ Natural and synthetic chemicals are added to improve/add leather properties
Dyeing	▪ Dyes are added to give color to the leather
Fatliquoring	▪ Oils and waxes are added for softening and lubrication
Drying	▪ Natural or forced drying, these days using advanced machinery
Finishing	▪ This is the process of converting the crust leather to finished leather

WET END PROCESSES



Wet end operations are **chemical and physical processes** that convert the wet blue (or wet white or vegetable) to crust, which is the dried leather. The typical steps are listed, and **chemicals need to be properly selected and balanced** to achieve the desired properties such as color, temper, elasticity, water repellency and softness; preparing leather for finishing

WASHING

With water, **degreaser and acid to uniformize the pH**, moisture and remove salts and natural fat. **Prepares the leather for the next steps.**

NEUTRALIZATION (Deacidification)

Made with alkaline salts and water to increase the leather pH and prepare for subsequent steps.

RETANNING

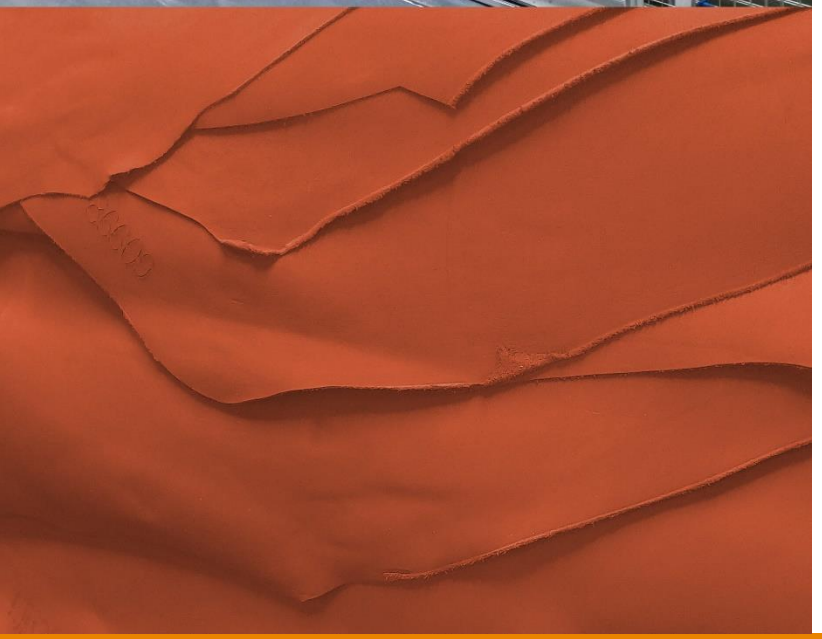
Chemicals are added to bond to the leather structure **to give properties of fullness, shape, color uniformity, temper, softness and stand.** Phenolic, naphthalene, melamine condensate products are widely used (syntans), as well as acrylic solutions, natural vegetable extracts, polymers and biopolymers. Metal salts of chromium III, aluminum and zirconium can be used too.

DYEING

Dyes are added to give color and color uniformity to the leather. The dyes used are **mostly acid dyes and metal complex dyes.** Proper selection of dyes is an art, made by a professional called the **Color Matcher.** The dyeing can be superficial or struck through.

WET END – continued





FATLIQUORING

Oil emulsions are added to **improve the softness and mechanical properties of the leather.** It is very common to use a mixture of different products to **achieve the properties required.** Shoe upper leathers may have **from 5% to 15% of solvent extractable materials** (oils); **upholstery leathers may have 20%.** The oils can be of **vegetable origin** (soy, rice, cotton, canola, coconut, etc.), **animal** (fish, tallow, lard) or **synthetic** (oil based and chemically modified). New polymeric materials have the **properties of both retanning and fatliquoring,** and their use is increasing.

DRYING

Drying is **one of the most important physical steps** in leather production.
The leather after wet end carries **almost 100% of its weight in water** and needs to be **reduced to 12-14%,** which is the typical moisture in crust and finished product. The drying starts with **setting out the leather,** a mechanical operation where **leather is squeezed** through rolls and a rotating blade to **reduce moisture and stretch the leather** before drying. The most common **methods of drying** are: air, toggling, vacuum, low temperature drying, tunnel. The slow process of air drying **makes the leather softer and very natural. New technologies have been developed** to improve the efficiency and uniformity of drying.

CHEMICALS COMMONLY USED IN THE WET END

Neutralization	▪ Organic and inorganic alkaline salts
Retanning	▪ Vegetable tannins, phenolic, naphtalenic and melamine resins, acrylic resins, biopolymers, fillers
Dyeing	▪ Mostly acid and metal complex dyes, synthetic
Fatliquoring	▪ Natural and synthetic oils and waxes. They are mostly chemically modified (sulfonation) so they can be emulsified in water

THE CHANGING APPEARANCE OF LEATHER
as it goes through the wet end



WASHING

Cleans the tanned leather intermediate (wet white, wet blue), uniformizes the moisture and pH, removes some natural fats and salts



NEUTRALIZATION

Reduces the leather's acidity and prepares it for retanning: **1 to 3% of chemicals are added here.**

Percentages are based on the shaved weight of the leather



RETANNING

A combination of retanning chemicals is added to **transform the leather's properties.** Typically, 10 to 30% chemicals are added at this stage



COLORING

Dyes are used **to give color.** Usually a **mixture of dyes** is used to **give the color.** A typical amount is from 0.5 to 4%



FATLIQUORING

Mixtures of **natural and/or synthetic oils and waxes** are added to **soften the leather.** Usually, the amount is between 6 and 20%

WET END MACHINERY



SET OUT

Wrings excess moisture from wet leather, reducing it to 50-60% and preparing the leather for splitting (Photo: vegetable leather).



SPLITTING

This machine is used to divide the leather into two layers, to separate the grain from the split (not used if leather is lime split).



SHAVING

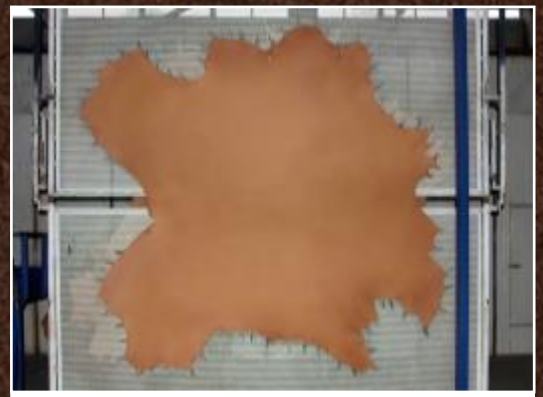
This makes the leather thickness uniform by shaving any excess away on the flesh side.



SAMMYING

The machine opens the leather after wet end processes and removes excess moisture, preparing it for the drying stages.

TYPICAL LEATHER DRYING METHODS



TOGGLE

Leather is hooked in a perforated screen that stretches to increase area. The screens are put on an oven for uniform drying



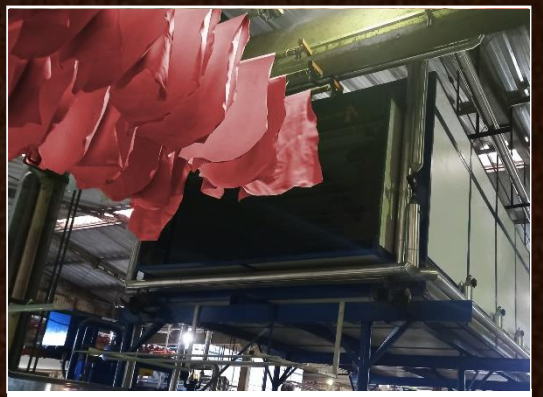
AIR DRYING

Leathers are hung on moving racks below the tannery roof, providing the most natural form of drying



VACUUM DRYER

Leather is stretched over a hot plate in a vacuum chamber and the water vapor is sucked out



OVEN DRYING

Leathers are hung up on racks as they are for air drying, and these racks go inside a hot air tunnel for forced – and quick – drying

TYPICAL FINISHING FLOW DIAGRAMS (UPHOLSTERY, SHOES AND LEATHER GOODS)

CORRECTED GRAIN FINISHED

Softening ▶ Buffing ▶ Basecoat ▶ Middle coat ▶ Topcoat ▶ Emboss ▶ Dry mill ▶ Toggle

FULL GRAIN FINISHED

Softening ▶ Basecoat ▶ Middle coat ▶ Topcoat ▶ Plate ▶ Dry mill ▶ Toggle

FULL GRAIN SEMI-ANILINE FINISHED

Softening ▶ Aniline coat ▶ Middle coat ▶ Topcoat ▶ Plate

CHEMICALS COMMONLY USED FOR FINISHING

Auxiliaries	▪ Surfactants, oil and wax emulsions, solvents, silicones. In some leathers. Oils and waxes can be used alone, without binders
Fillers	▪ Clays, silicas, organic polymer particles for filling or dulling
Pigments	▪ Organic and inorganic pigment dispersions, finely ground
Dyes	▪ Metal complex dye solutions
Binders	▪ Acrylic and PU (polyurethane) emulsions producing soft to hard films, natural proteins (eg, casein) and modified natural cellulose

FINISHING

THE MAIN STEPS

BUFFING (Sanding)

Like wood, leather can be sanded with different grades of sandpaper t**o create different superficial textures.** The degree of buffing can be minimal with fine paper **to reduce surface imperfections or deep,** where a strong buffing with coarse paper produces a nap effect, found in nubucks and suede.

OILING AND WAXING

Oils and waxes can be **applied alone or combined.** It is usual to apply it **hot to one or both sides of the leather using a roll coater.** The oils and waxes can add softness, color, feel, pull up effect and waterproofness to the leather. Oiled or waxed leathers can also take film forming treatments as an additional coating.



Here we have a **great variety of mechanical and chemical steps** applied to the crust to make the leather ready for use. Finishing is a **blend of artistry, chemistry and great skill.** The process adds protection, color, gloss, texture, feel and appearance to the leather

FINISHING
– continued

COATINGS

Leathers can have one or multiple coatings, depending on the properties required. **Most of the time the coatings are film forming;** typically, leathers have a pigmented base coat and intermediate coat and a transparent topcoat. **Oil and wax** coatings are not film forming.

Coatings are applied by spray, roll coaters and paper transfer and are mostly water based.

Most of the finishes are made with binders (acrylic or PU emulsions); these can be soft, medium hard and hard. Protection is built up in layers, starting with **soft coats for elasticity** and ending up with **a final hard topcoat**.

THE BASIC COATING COMPONENTS ARE WATER-BASED

Film-forming products

Binders: acrylic and polyurethane water emulsions

Pigments

Very finely ground colored solid particles

Inerts

Fillers and dullers used to modify the film, particularly the gloss

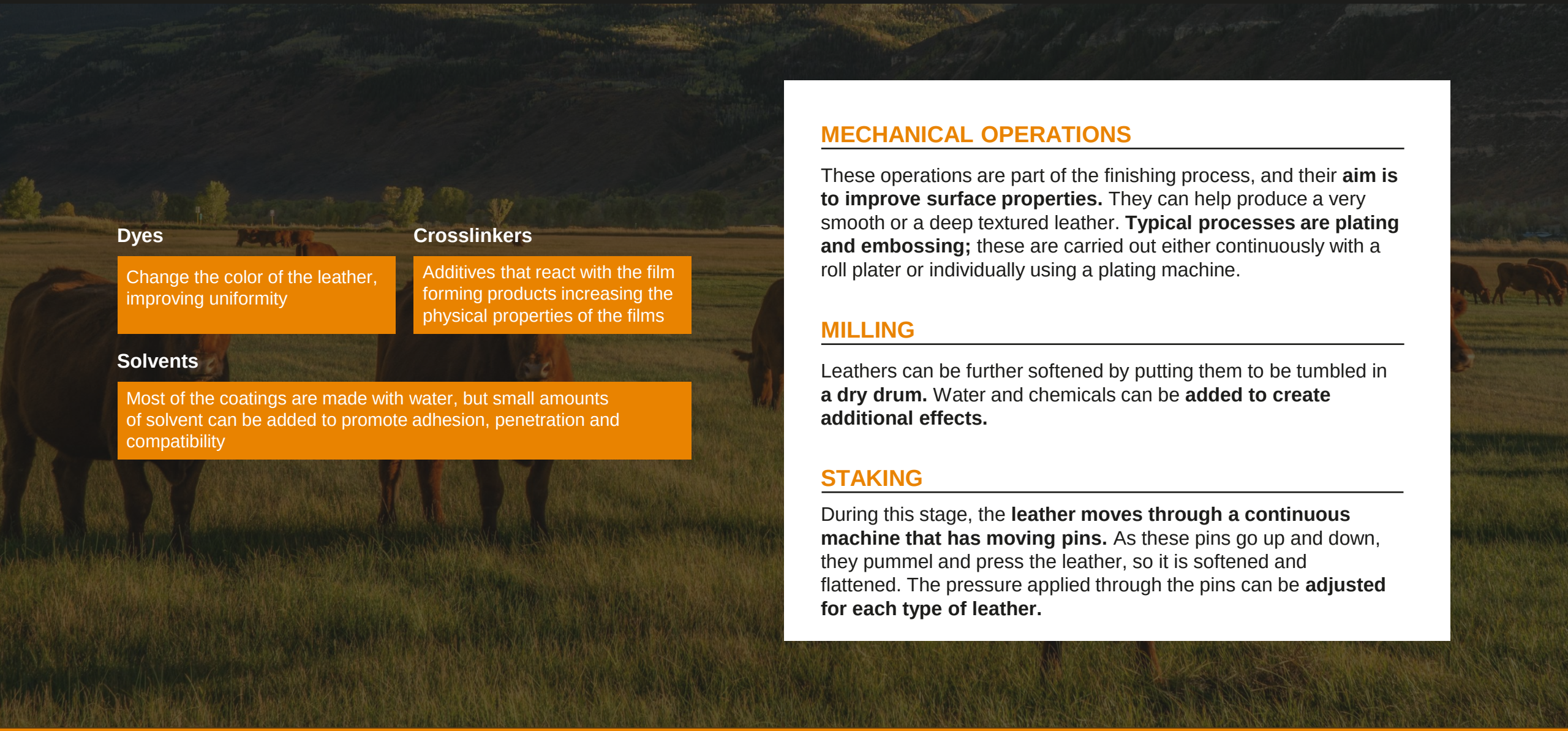
Softening agents

Oils and/or wax emulsions that soften the film and improve its elasticity

Feel modifiers

Additives that enhance the leathers' haptic properties

FINISHING
– continued



Dyes

Change the color of the leather, improving uniformity

Crosslinkers

Additives that react with the film forming products increasing the physical properties of the films

Solvents

Most of the coatings are made with water, but small amounts of solvent can be added to promote adhesion, penetration and compatibility

MECHANICAL OPERATIONS

These operations are part of the finishing process, and their **aim is to improve surface properties.** They can help produce a very smooth or a deep textured leather. **Typical processes are plating and embossing;** these are carried out either continuously with a roll plater or individually using a plating machine.

MILLING

Leathers can be further softened by putting them to be tumbled in **a dry drum.** Water and chemicals can be **added to create additional effects.**

STAKING

During this stage, the **leather moves through a continuous machine that has moving pins.** As these pins go up and down, they pummel and press the leather, so it is softened and flattened. The pressure applied through the pins can be **adjusted for each type of leather.**

COATINGS APPLICATION EQUIPMENT – SPRAYS

SPRAY MACHINES

Water- and solvent-based finishes are sprayed on to the surface of the leather, then dried. Machines are designed for high throughput while minimizing energy use and emissions.



Spray machines can be assembled in tandem with driers to maximize their efficiency, versatility and productivity.

SPRAY GUNS

High tech devices that work together with sophisticated sensors to read the leather's shape correctly and trigger the guns to go on/off, minimizing waste and optimizing uniformity.



Systems may have up to 24 guns. They need to be calibrated and cleaned to maintain their performance.

COATINGS APPLICATION EQUIPMENT – ROLL COATERS

ROLL COATERS

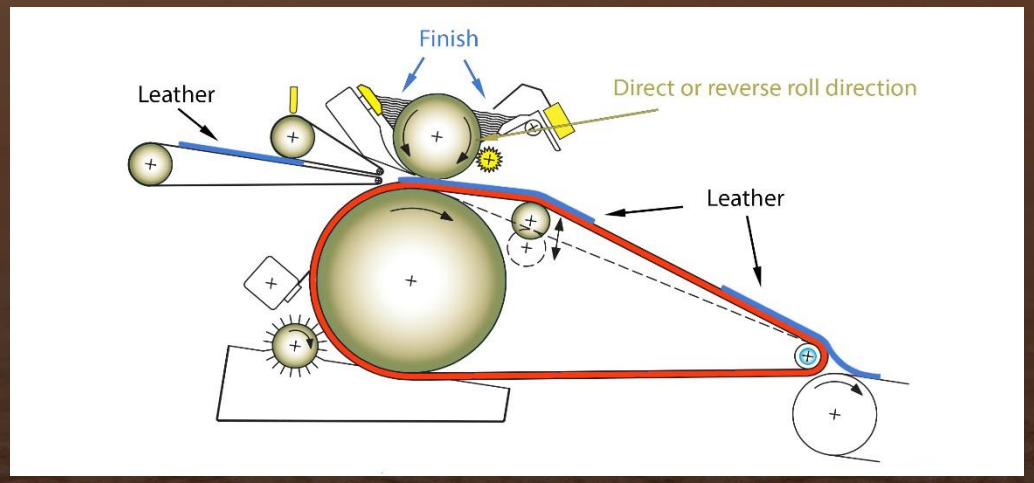
Water-based finishes, melted waxes and oils are applied through engraved rolls with designs that allow light or heavy deposition. Waxes and oils can be heated to speed up absorption and improve distribution uniformity.



Two full size roll coaters working in tandem. Operators can feed in two sides or one full-sized leather at a time.

ENGRAVED ROLLS

Engraved rolls are engineered to produce a uniform finish distribution on the leather and to minimize waste. Depending on the roll, it's possible to engrave from light to heavy finish depositions. Finish effects are also possible with design rolls.

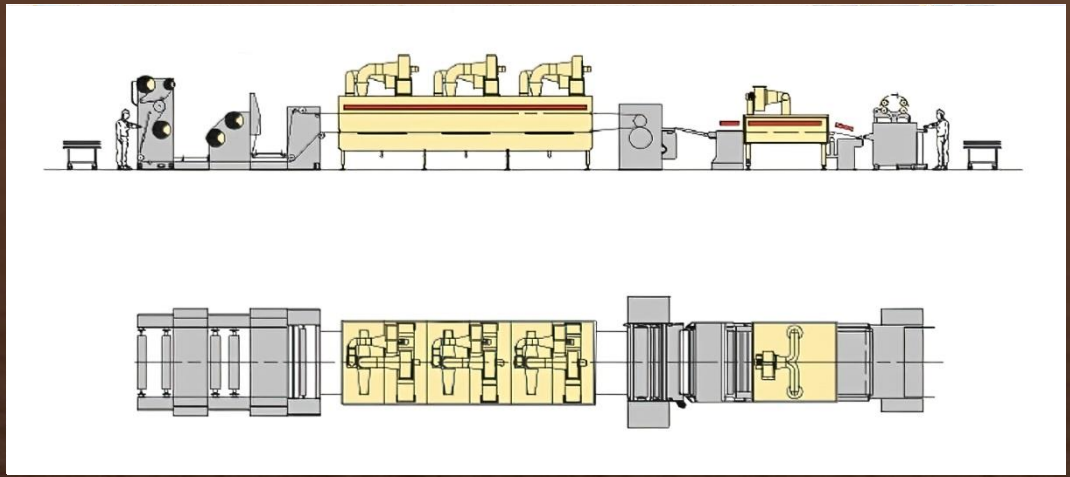


Rolls can run in reverse for heavier depositions or directly for lighter depositions or effects.

COATINGS APPLICATION EQUIPMENT – PAPER TRANSFER MACHINES

PAPER TRANSFER MACHINES

An adhesive is roll coated to the leather; a release paper is roll coated with finish. The leather is pressed to the coated release paper to transfer the finish. After drying the leather is peeled off the paper release, leaving the finish in place.



This method produces uniform leathers with excellent mechanical properties, with little waste and low labor input.

RELEASE PAPER

Release paper can be smooth or textured to simulate leather or additional effects. The leather can be released from the paper manually or automatically. For re-use, the finish is removed mechanically from the areas without leather.



The release papers can be used 20 to 40 times in this rapidly advancing technology.

OTHER FINISHING MACHINES



STAKING *(Molisa™)*

Softens the leather by moving the leather continuously through vibrating pins.



MILLING

Is another way to soften the leather by tumbling it in dry drums. Water and chemicals can be added to produce further effects on the leather.



BUFFING

Is the superficial sanding of the leather to uniformize the surface, reduce defects and create effects.



EMBOSSING OR PLATING

Is used to smooth the leather, or create textures by embossing it. Deep embossing effects are possible with this machine.



ROLL PRESS

Is a continuous machine that smooths the leather surface and can create light textures, gloss or embossing.



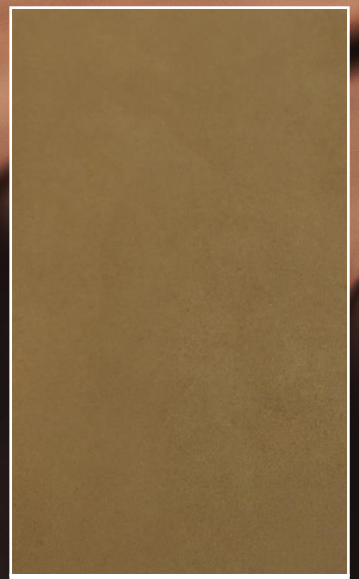
MEASURING MACHINE

Is an electronic device that measures the area of each piece and stamps the measurement on the back of the leather.

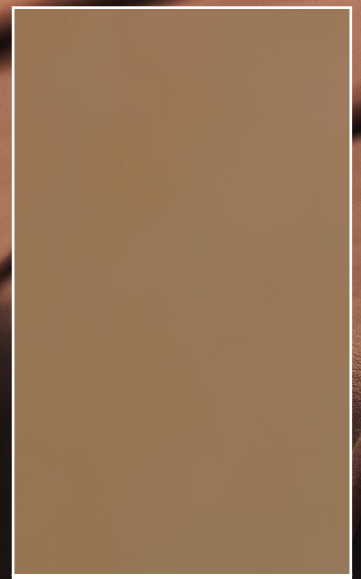
HOW DIFFERENT STAGES OF FINISHING APPEAR
from crust to topcoat



CRUST AFTER SANDING



DYE STAIN



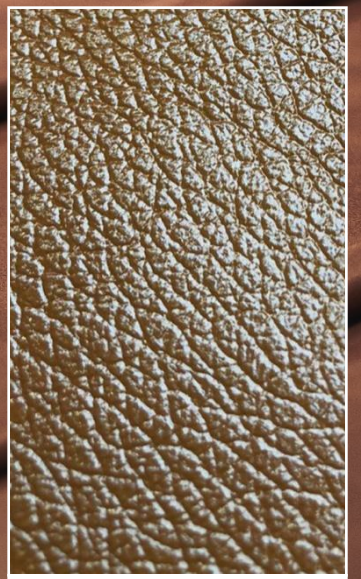
SEALER COAT



BASECOAT



EMBOSSING



GLOSSY TOPCOAT

TYPES OF FINISHES



DIFFERENCE BETWEEN DYE AND PIGMENT

Lorem DYE

(soluble in water or solvent, transparent)

Ipsum PIGMENT

(insoluble particles dispersed in water, non-transparent)

BASIC TYPES OF FINISHES (REPRESENTATION)



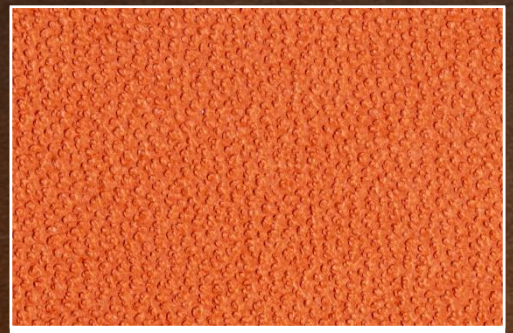
Aniline
- Transparent coat

Semi-aniline
- Low pigment coat
- Transparent coat

Semi-pigmented
- Medium pigment coats
- Transparent coat

Pigmented
- Full pigment coats
- Transparent coat

THE MAIN FINISHED LEATHER TYPES



ANILINE

These leathers require the best grades and are the most expensive. They look very natural; dyes can be applied alone or with a transparent finish that may include oil and waxes. In the best examples all leather pores are visible. This leather type must not be sanded



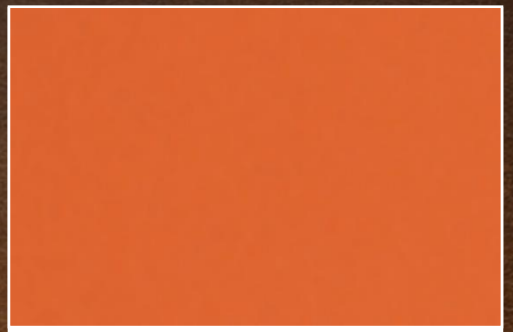
SEMI-ANILINE

Small amounts of pigments are added to the coating, reducing the transparency and uniformizing the leather to improving the cutting yield. These leathers are still high value and can be used in very expensive leather articles. The leather pores are still visible



SEMI-PIGMENTED

More pigments are added to the coatings to improve the uniformity. The leather pores are less visible, and quality is still high



PIGMENTED

Additional pigment coats are applied to the leather and pores are not visible. Stamps can give effects to simulate pores or other textures. These leathers have much better cutting yield and are still valuable. Many automotive leathers come from this category

Note: Crust type and quality, thickness, finish and mechanical operations dictate the price of the finished product. All these types can produce outstanding quality, high value leathers

EMBOSSING EFFECTS
– creating textures



CURRENT INTERNATIONAL STANDARDS
for leather testing

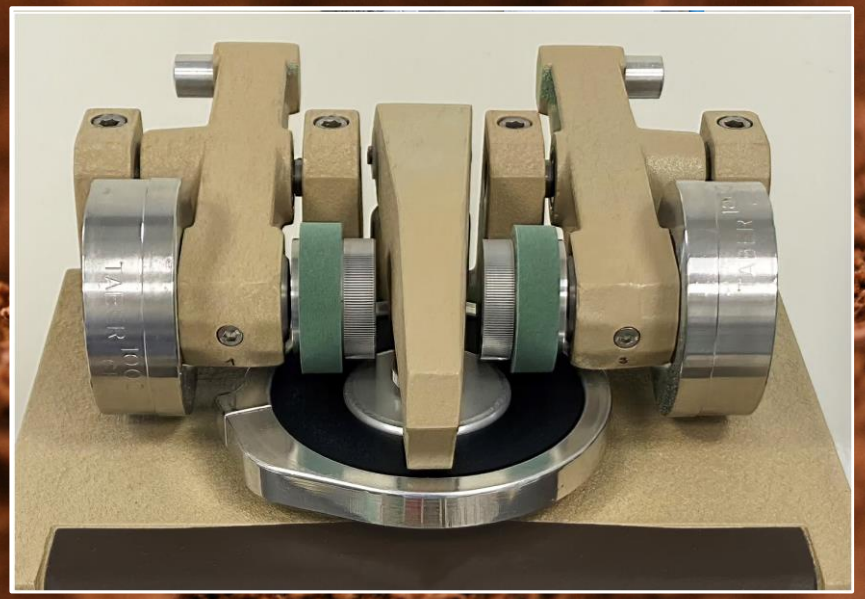


- **The IULTCS** (International Union of Leather Technologists and Chemists Societies) has a special **agreement with ISO** (International Organization for Standardization) which means that there are **special ISO Standards** unique to leather testing that take into consideration all the material's properties. ISO **recognizes IULTCS as the international standardizing organization** for leather test methods.
- Leather test methods.
- ISO Standards are adopted globally as the **basis for local national standards.**
- **Almost 100 leather specific procedures** have been developed and approved as ISO Standards.
- **Examples include standards** for measuring area, tensile and tear strength, dimensional shrinkage, heat resistance, water repellence, fogging, flame resistance and color fastness, **as well as a range of chemical tests** for leather.
- **The list of leather test methods** can be found at https://iultcs.org/wp-content/uploads/2020/10/IULTCS-ISO-EN_Leather_test_methods_Oct-2020.pdf
- **The international methods developed by ISO and IULTCS** are available at https://www.iso.org/store.html . **Other national standards are ASTM** in the United States https://www.astm.org/ **and DIN** in Germany https://www.din.de/en/about-standards/buy-standards .

CURRENT INTERNATIONAL STANDARDS
for leather testing – continued



Flexing Resistance Test



Taber® Abrasion Test

CURRENT INTERNATIONAL STANDARDS
– basic leather physical and fastness testing

- **Identification of leather with microscopy** (ISO 17131 / IUP 56)
- **Thickness** (ISO 2589 / IUP 4), **surface coating thickness** (ISO 17186 / IUP 41)
- **Tensile strength** (ISO 3376 / IUP 6)
- **Shrinkage temperature** (ISO 3380 / IUP 16)
- **Water vapor permeability** (ISO 14268 / IUP 15)
- **Water absorption** (ISO 2417 / IUP 7)
- **Water resistance – Penetrometer** (ISO 5403-1 / IUP 10-1) **& Maeser** (ISO 5403-2 / IUP 10-2)
- **Tear load – single edge** (ISO 3377-1 / IUP 40), **– double edge** (ISO 3377-2 / IUP 8)
- **Stitch tear resistance** (ISO 23910 / IUP 44)
- **Dimensional change** (ISO 17130 / IUP 55)
- **Abrasion resistance** (ISO 17076-1 & 17076-2 / IUP 48-1 & 48-2)
- **Flex resistance** (ISO 5402-1 / IUP 20-1)
- **Soiling resistance** (ISO 26082-1 / IUP 53)
- **Surface area measurement** (ISO 19076 / IUP 58)
- **Fogging** (ISO 17071 / IUP 46)

BASIC LEATHER CHEMICAL ANALYSIS

- **Moisture** (ISO 4684 / IUC 5), **expressed as %. Typical values are 12 to 14%**
- **pH** (ISO 4045 / IUC 11), **expressed in units – for wet blue, 3.6-3.8; for crust leathers, above 5.0**
- **Chrome content** (ISO 5398 Parts 1 to 4 / IUC 8), **expressed in % Cr_2O_3** (from 0% for chrome-free leathers, others up to 4.0%)
- **Ash content** (ISO 4047 / IUC 7)
- **Fats and oils** (ISO 4048 / IUC 4) **– materials extractable by dichloromethane: typical values are between 5 to 20%**
- **Critical chemicals in leather** (ISO 20137 / IUC 36)

PROPERTIES OF A GOOD SHOE LEATHER

Shoe and boot leather comprises the widest range of leathers globally. There is a vast diversity of color, texture, gloss, thickness, embossing and surface appearance. The surface ranges from full grain aniline, to corrected grain, semi-pigmented and fully pigmented. Many types of splits are also used as suede or finished split, including the PU-covered split that is very fashionable for the white sports shoes and trainers.

The main categories are based on thickness: women's shoes are made with thin leathers of 1.0 mm to 1.4 mm; men's shoes with 1.4 mm to 2.2 mm.

The unique properties of leather give it many advantages, properties such as water vapor permeability and water absorption, which make leather a great choice for foot comfort and hygiene. No other material has the same abilities. Shoe leather **can be cleaned and repaired easily** to restore its natural beauty and characteristics. As it ages, leather molds to the shape of the foot like no other material, adding an even higher level of comfort. Leather shoes are also compatible with **high tech waterproof membranes** and **can be fully waterproofed** for outdoor use**.**



PROPERTIES OF A GOOD SHOE LEATHER 2

The leather used to make shoes needs to be adaptable around the different methods of construction, eg, white leather needs to be compatible with high temperatures, vulcanization materials or PU injection processes; boot leather **must have the correct elasticity and strength to be lasted**; cemented leathers need the proper amount of extractables for strong adhesion, and pull up leather must maintain its characteristics after construction.

Many leathers have touch up treatments to adjust color, gloss, surface and feel.



PROPERTIES OF A GOOD SHOE LEATHER 3

These are typical shoe leather parameters

The type of leather, processing and finishing define the parameters and need to be properly adjusted for each type of construction and for the size of the shoe. Leather thickness, temper, oil content and moisture are the important variables that can affect the mechanical and physical properties of the leathers (see Test Methods section for more details).

Tear strength	**Stitch tear strength**	**Burst strength**	**Slot tear resistance**	**Heat fastness**	**Light fastness**	**Dye migration**
Water-proofness	**Soil resistance**	**Finish adhesion**	**Water absorption**	**Flex resistance**	**Water vapor permeability**	**Elongation**

PROPERTIES OF AUTOMOTIVE LEATHER

Automotive leather is the most durable material for car interiors as it is easy to clean, easy to maintain and is biodegradable.

Over the last two decades the demand for automotive leather has increased substantially as it is valued as a sustainable material.

Automotive leather is **used for different car interior components such as seat covers, head rests, door panels, steering-wheel, dashboard and gear shift.**

Leather properties and requirements differ, depending on usage, and that includes the use of chrome tanning or chrome-free leathers. Automotive leathers **usually range from 1.1 to 1.3 mm thick.**

The main types of automotive leathers are:

SMOOTH LEATHER NAPPA

Lightly finished = they are **known as 'full-grain'** leathers with a softer and more natural feel.

EMBOSSED ARTICLES

Full finishing = they are **heavy coated** with a more uniform surface pattern and are normally less soft to the touch.

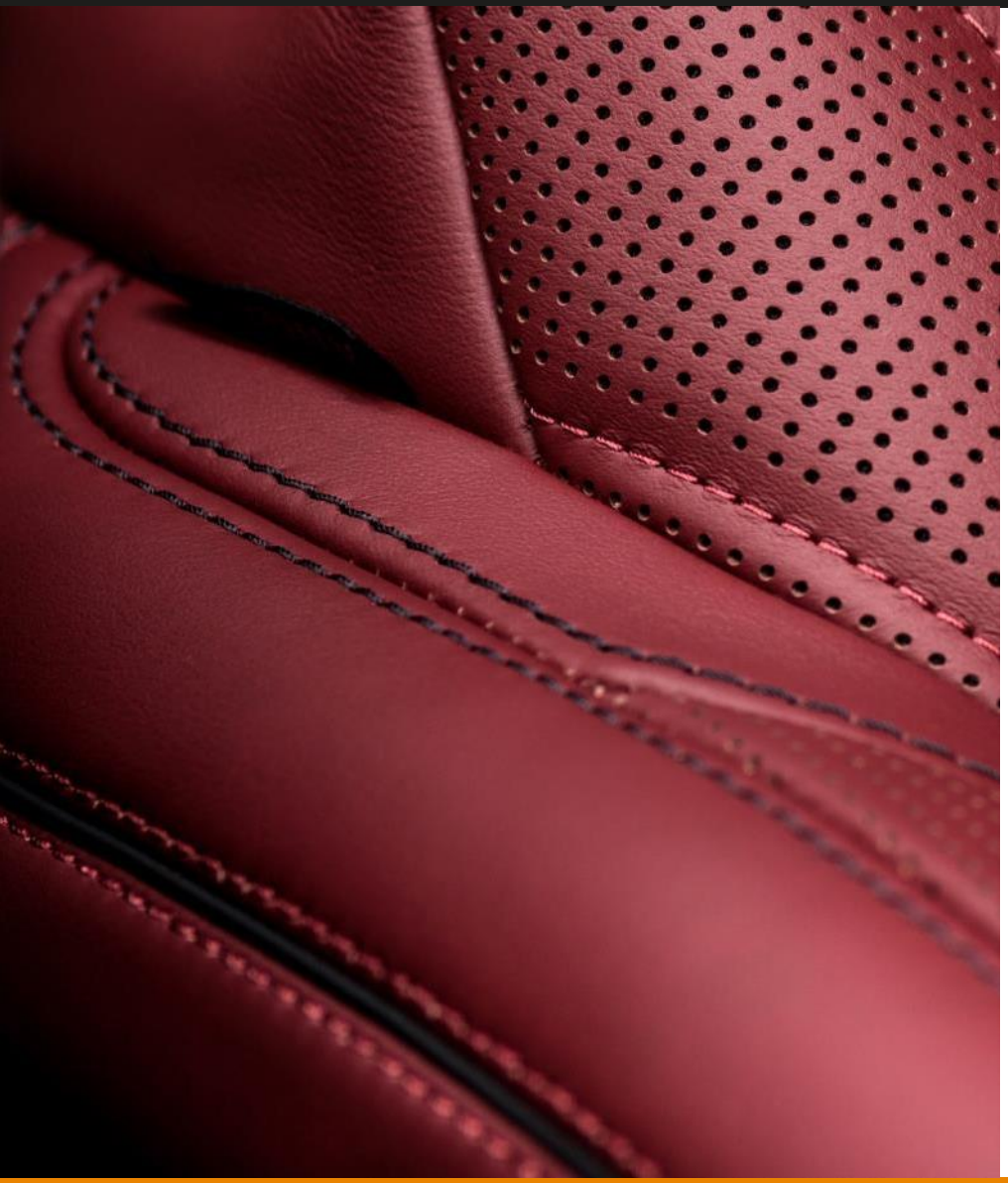
Important property:

DURABILITY

Automotive leathers can vary widely when it comes to **surface structures** or the type of **feel,** from **dry** to **smooth, waxy** or **silky.** They may vary on **gloss** and **color** depending on the carmaker or model. But there is one pattern all automobile leathers follow and that is **durability.** No other car interior stands for **durability** and **luxury** as much as leather does.

Eg, Ford's Model T can still be admired with its original leather seating, as can many other classic cars.

PROPERTIES OF AUTOMOTIVE LEATHER 2



Other leather variations include:

PERFORATED LEATHER

Perforation is a matrix of holes in regular intervals on the surface of the leather. Leather car seats are perforated to allow better breathability through the pigmentation and to allow moisture to be released more effectively and reduce sweating. **Perforations also support the effect of seat heating or seat cooling systems.**

LAMINATED (backing)

Laminated leather means coating or glueing something to the back. This backing can be made with a different type of leather, but also with films, foams or linings. The lamination is done for protective reasons, to reinforce the leather and to reduce leather stretching that could lead to ‘bagginess’.

Each OEM (Original Equipment Manufacturer) sets their proprietary physical and chemical specifications; they are continually updating and making the specs more and more difficult to achieve. The most common properties are VOCs (Volatile Organic Compounds), fogging, smell, specific weight, light fastness, ageing resistance, wet and dry, perspiration resistance, etc.

The important physical properties are tear strength, scuffing resistance, abrasion and flex resistance.

Technical challenges: dimensional stability and resistance to soiling (denim dye transfer, sunscreen, coffee spills)

Flammability test is also a requirement measuring the burn rate of the leather along a horizontal plane. Typically, the burn rate will be required to be below 80 mm/min.

PROPERTIES OF UPHOLSTERY LEATHER

Customers see leather as a desirable natural material with a higher value than alternative upholstery coverings.

Modern upholstery leathers are **extremely comfortable, durable** and **easy to maintain. They** are invariably based on bovine hides as these offer the size, substance and longevity required.

Leather is the most responsible and sustainable choice for upholstery and is the original performance material. It is a diverted by-product of the meat industry, meaning the hides do not go to waste. And leather's unique strength and long lifespan help it to outperform the alternatives available on today's market.

Several standards exist for upholstery leathers, such as: ISO, CEN, National Standards outside the EU, retailer specs, in-house specs, specific national requirements/legislation.

Requirements fall into several broad categories:

PHYSICAL	CHEMICAL	FASTNESS	FLAMMABILITY	CLEANING	OTHERS
Strength-tear, tensile, abrasion wear. Permeability and absorption. Seam holding and buttoning. Bagging/ deformation. Flex cracking/cold crack	Restricted Substances List (RSL)	Light – Xenon Arc, water-rubbing test, fogging, dye transfer-staining	Is a legal requirement in some markets such as the UK and USA (varies by state). Methods and techniques vary	Soiling test, solvents and detergents	Faults, area measurement, ageing, odor, labeling (eg, coated leather). Emissions (VOCs)

Performance levels may be determined by:

a) LEGAL REQUIREMENTS

CEN have established a category for furniture in the European Community's Eco-Label awards. The award's criteria aim to promote a **reduction in the environmental impact of furniture manufacture** such as: reduction in the use of hazardous substances, reduction of pollutant emissions and the quality of the effluent from tannery. Indoor air quality is an environmental concern because a furniture manufacturer may use the wrong adhesive or the wrong finish and this can affect the VOCs.

b) LEATHER TYPES

Aniline, Semi-Aniline, Pigmented, Nubuck, Suede

c) END-USE (FITNESS FOR PURPOSE)

Occasional (less demanding), light domestic, heavy domestic, contract and hospitality (more demanding), private aviation and high-end automotive refurbishment

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Over the years there has been a clear trend of extending leather upholstery into mass transport, such as on airplanes and sea-liners.

PROPERTIES OF UPHOLSTERY LEATHER 2

A good quality piece of furniture will have full or corrected grain leather or upholstery grade suede throughout.

Finishes vary from pure aniline to pigmented and possess a variety of characteristics. End use selection is dependent upon client preference.

Pure aniline and waxed or oiled finishes have become a standard in all project types, bringing the leather's natural characteristics and patina into the interior, regardless of its level of use. Top selection is highly valued to accentuate natural characteristics, particularly for aniline leathers. When clients prefer a leather less likely to patina, they may choose a more consistent semi-aniline or pigmented finish.

EXAMPLES OF GENERAL NON-RESIDENTIAL APPLICATIONS

Corporate task chair – typically semi-aniline or pigmented

Executive chairs or conference room – all types, depends on owner/designer preference

Lobby or lounge pieces – have more budget dollars and are open to all finish types including specialty leather options, depending on preference

Hospitality and residential – all types, regardless of traffic level, depends on owner/designer preference

Aviation – private or corporate jets use semi-aniline or pigmented leather on seats, and whatever they like on accent areas, lower sidewalls, bulkheads, etc. Commercial airlines use heavily pigmented and sometimes bonded or even faux products

Vertical use – upholstered headboards or wrapped leather wall panels are sometimes used in a range of projects. These can be padded, stitched, quilted or directly glued to a substrate and then attached to the frame or wall

LEATHER CUTTING

Leather is a natural product, which means it does not have a uniform outer contour, there are variations and not all areas are of the same quality or grain pattern. The art of cutting leather lies in the optimal area yield, while taking all these aspects into consideration. **A cutter must check the leather on both sides for defects.** These can be discoloration or damage such as scarring or insect bites. Cutting lines must be chosen so that the finished objects have a similar grain pattern**. Always mindful of waste, a cutter must also select the better parts of the leather that will make the premium parts of the article** (vamp for shoes and seats and upholstered armrests).



For automotive and furniture upholstery current technologies include slitting knives, manual cutting, die press techniques and laser cutting. **Die cutting in conjunction with electro-mechanical technology has grown significantly** over recent years for several reasons: it is flexible, offers high production speeds, enables complex geometric cutting, customization, and it creates less waste. Altogether, these advantages make die cutting more and more economically attractive for leather cutting applications.



There are various machines for cutting leather and, with the aid of lasers, it is possible to detect the external contours of the leather and mark up any areas of damage. **Computer programs then calculate the optimal cutting.** The leather is then aligned correctly on the cutting table against a light template taken from the scanning of the outer contour. The leather is then sucked on to the table by vacuum and the cutting automatically performed by a knife or high-pressure water jet.

COLOR MANAGEMENT
in the tannery

LEATHER NATURALLY

Color is one of the most important parameters for leather

Standard swatches are made to be the color and article reference.
Color can be visually compared to the standard in a calibrated light source.



White light temperatures can be selected for proper visual color comparison on the light cabinet.





International color standards can be used as reference.

COLOR MANAGEMENT
in the tannery 2



Color can also be measured by spectrophotometers where color is measured and expressed in a color space, eg, CIELAB. This way the color can be measured and compared to the stored standard and transmitted and stored digitally

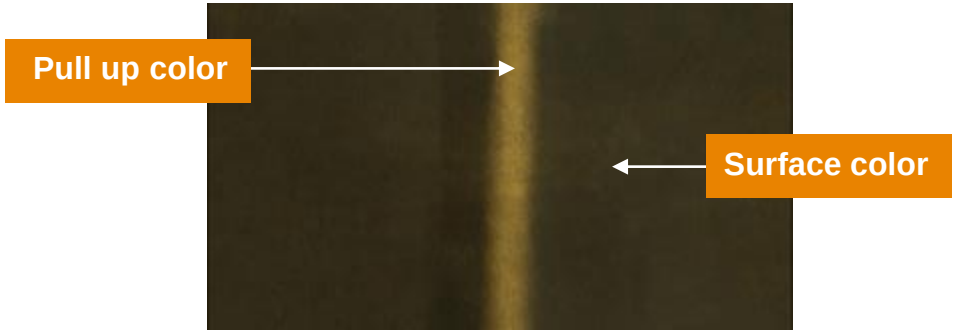
LAB SPECTROPHOTOMETER



PORTABLE SPECTROPHOTOMETER FOR USE IN THE TANNERY



PULL UP LEATHERS HAVE A DIFFERENT COLOR WHEN FOLDED (PULL UP COLOR). SURFACE AND PULL UP COLOR NEED TO MATCH



CHEMICAL MANAGEMENT
in leather manufacture



MANAGING CHEMICAL INPUT

Leather is made by tanning animal hides using water and chemicals (eg, salts, acids, tannins, dyes, oils, finishing products, processing auxiliaries, etc). Chemicals are present in leather and its by-products (fat, proteins and salts) as well as in wastewater and gaseous emissions, so the right selection of chemicals is important and requires reliable, fact- and science-based toxicological and eco-toxicological information. Using the latest information for product selection, risks for workers, consumers and the environment can be minimized.

The use of chemicals in leather manufacturing is highly regulated and controlled. Many governments and brands have imposed strict chemical compliance regulations on manufacturers. One of the most prominent legislations is the EU REACh directive, which governs the manufacture and importation of chemicals in the EU.

An example of an influential non-governmental regulation body is the ZDHC Foundation https://www.roadmaptozero.com/ **. The ZDHC Road to Zero program is supported by more than 120 global brands, manufacturers, testing institutes and suppliers, and periodically issues an updated MRSL** (Manufacturing Restricted Substance List) aimed at restricting the use of chemicals to be used intentionally in chemical formulations in the leather and textile manufacturing supply chain. The MRSLs inform the chemical manufacturers on maximum allowable levels of specific substances present in a formulation.

Finished leathers must comply to the customer's chemical restricted list, called RSL.

Another example of **influential non-governmental regulation body is OEKO-TEX®** https://www.oeko-tex.com/

CHEMICAL HANDLING
in the leather industry



ANY CHEMICAL SUBSTANCE,

be it synthetic or natural, requires strict handling procedures to be observed. This starts with **monitoring** and **record keeping of chemical inventories**, **storage of chemicals** (temperature, humidity, separation of reactive chemicals, etc) and **training of workers and operators** on chemicals handling and personal protective equipment. We have seen examples on the internet showing pictures of workers handling (leather) chemicals in unsafe conditions and not using any personal protective equipment. Those situations are the exception, and most brands and manufacturers require tanneries to pass third party environmental stewardship audits which define good standards for operational safety and chemical handling.

Responsible chemical manufacturers also conduct special training for workers and operators where general and specific chemical know-how is provided. Furthermore, UNIDO, EU (BAT – Best Available Technology document) have **prepared excellent guidance documents for safe and responsible leather manufacturing.**

MAIN UNITS
in the leather industry

MATERIAL	MAIN PARAMETERS THAT DEFINE THE QUALITY AND PRICE	UNITS (HOW IT IS SOLD)
Raw hide	Type*, size, grade, origin**, weight range, curing method***	Piece, weight (lb. or kg), ft^2, m^2
Wet blue	Type*, size, grade, thickness	Piece, ft^2, m^2
Crust	Grade, thickness, color	ft^2, m^2
Finished	Grade, finish type, thickness, color, cutting area	ft^2, m^2

* Type: eg, native cow, branded cow, heifer, steer, Texas steer, bull, etc
** Origin: geographic location (also local)
*** Curing method: cold, ice, brine or salting

CONVERSION UNITS	
1 ft^2	0.0929 m^2
10.764 ft^2	**1 m^2**

CONVERSION UNITS	
1 lb.	0.4536 kg
2.2046 lb.	**1 kg**



TYPICAL BIODEGRADABILITY TESTS
for leather and synthetics



EN ISO 20200:2015

PLASTICS

- Determination of the degree of disintegration of plastic materials
- Test lasts between three and six months

EN ISO 20136:2020

LEATHER

- Determination of degradability by micro-organisms
- Test lasts one month and monitors CO_2 release

Ecotox testing

- Determination of toxin levels in leather-containing compost
- Four months

Plant response test

- Assessment of plant growth in leather- or chemical-containing compost
- Four months

LEATHER BIODEGRADABILITY

- **All leather is biodegradable/degradable.** For example, very few ancient Egyptian, Chinese, Indian, Greek and Mesopotamian leathers have survived from antiquity
- **The breakdown time varies –** with a commonly quoted time 0.05 to 45 years
- **Type and degree** of tannage, re-tannage, finish composition and thickness **affect leather's biodegradability**
- **The tannage order of biodegradability:** vegetable (least) < chromium < wet white < *chamois* (most biodegradable)
- **New biodegradability studies** are being carried out now and, in a few months, we will have more data



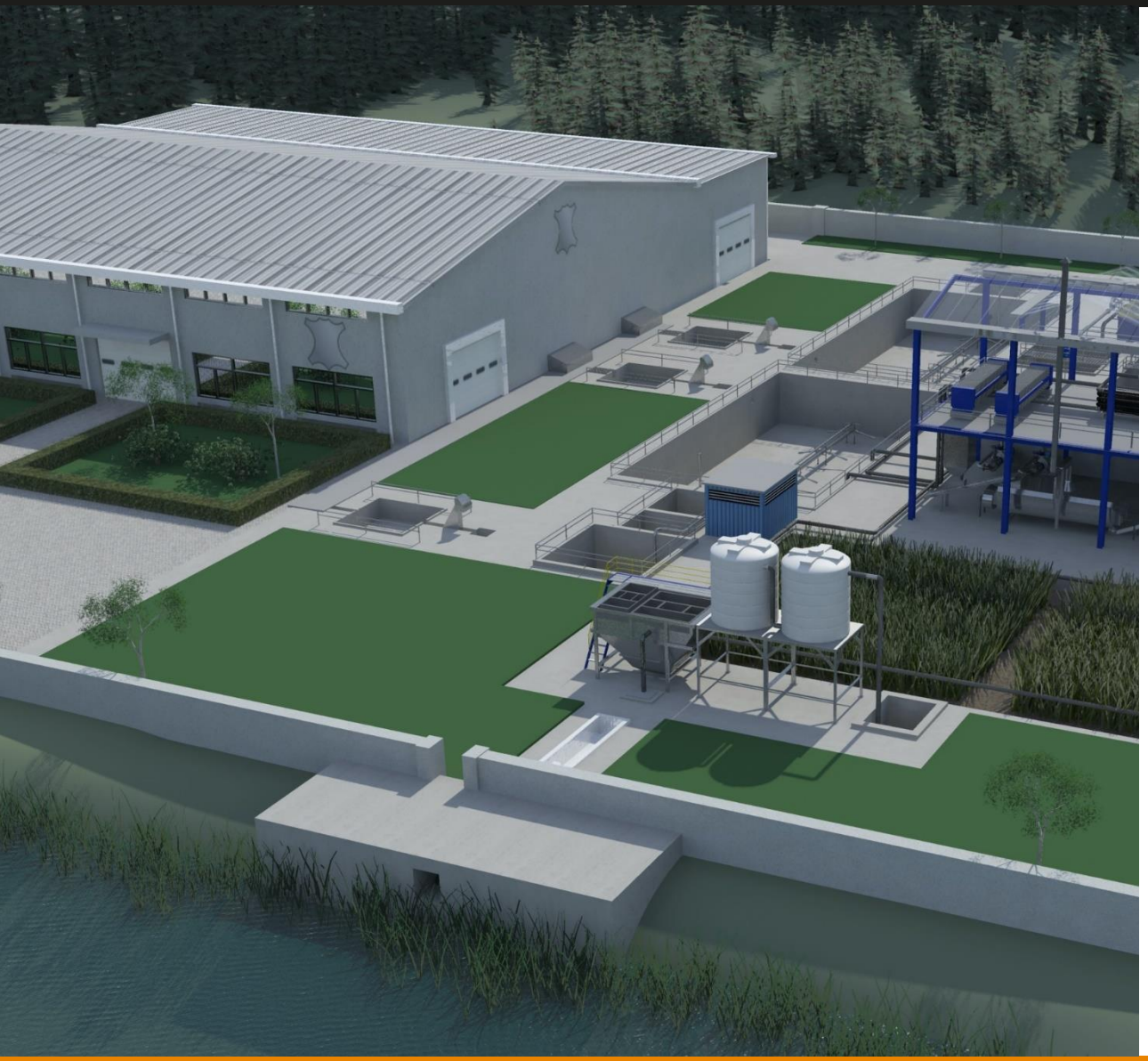
TABLE OF ESTIMATED BIODEGRADABILITY*

Material	Time in Years	Material	Time in Years
PVC	Forever	**Acrylic**	10 to 100
Polystyrene	+ 1,000	**Leather**	0.05 to 45
Polypropylene	+ 1,000	**Paper**	2 to 5 months
PE Low density	100 to 1,000	**Cotton**	1 to 5 months
Polycarbonate	100 to 500	**Banana peel**	10 days
Polyester and PU	20 to 200		



***** This is an estimate only. There are numerous variables in the materials and the conditions of biodegradability which are not directly comparable.

BEST ENVIRONMENTAL PRACTICES
for tannery effluent treatment



Tannery wastewater is a complex mixture of organic substances derived from the hide and organic and inorganic substances which are added during leather processing. The challenge for tanneries is to **reduce environmental impacts by:**

improving chemical uptake	**reducing** chemical and water use	**Increasing** efficiency of treatments
recycling process chemicals and water	**reducing** energy requirements	**reducing** emissions and sludge generation

Tanneries worldwide are continuously improving their environmental performance and are modernizing their effluent treatment plants to fulfil consumer demand, to achieve strict new norms and regulations and to continuously improve their environmental situation and sustainability.

Key current environmental technologies applied by tanneries are shown on the IUE webpage:

https://iultcs.org/tannery-effluent-treatment-videos

KEY TECHNOLOGIES
for tannery effluent treatment










Key technologies for tannery effluent treatment

- Effluent segregation of chrome and sulfide-bearing liquors to recover chrome and oxidize sulfides
- Fine screening to reduce solids and aerated balancing to neutralize and reduce odors
- Primary treatment with dissolved air flotation to efficiently remove suspended solids and non-biodegradable COD
- Biological treatment with denitrification and nitrification to remove ammonia and total nitrogen
- Membrane bioreactor to remove micro-pollutants
- Nano filtration for water recycling
- Sludge de-watering to reduce sludge volumes and disposal costs

Sustainable solutions to reduce carbon footprint

- Reed beds for tertiary treatment
- By-product utilization: recovery of chrome, gelatin, tallow
- Waste to energy: biogas, gasification
- Solar power water heater
- Rainwater collection

LEATHER REPAIR AND REDRESSING

Repairability is one of leather's best qualities.

Leather articles can be rejuvenated at home with the simple use of consumer polishes, stains, waxes and oils. Even waterproofness can be restored with consumer grade products. Professional repair work is available all over the world when any mechanical damage to a leather item needs doing. Here are some examples of before and after:



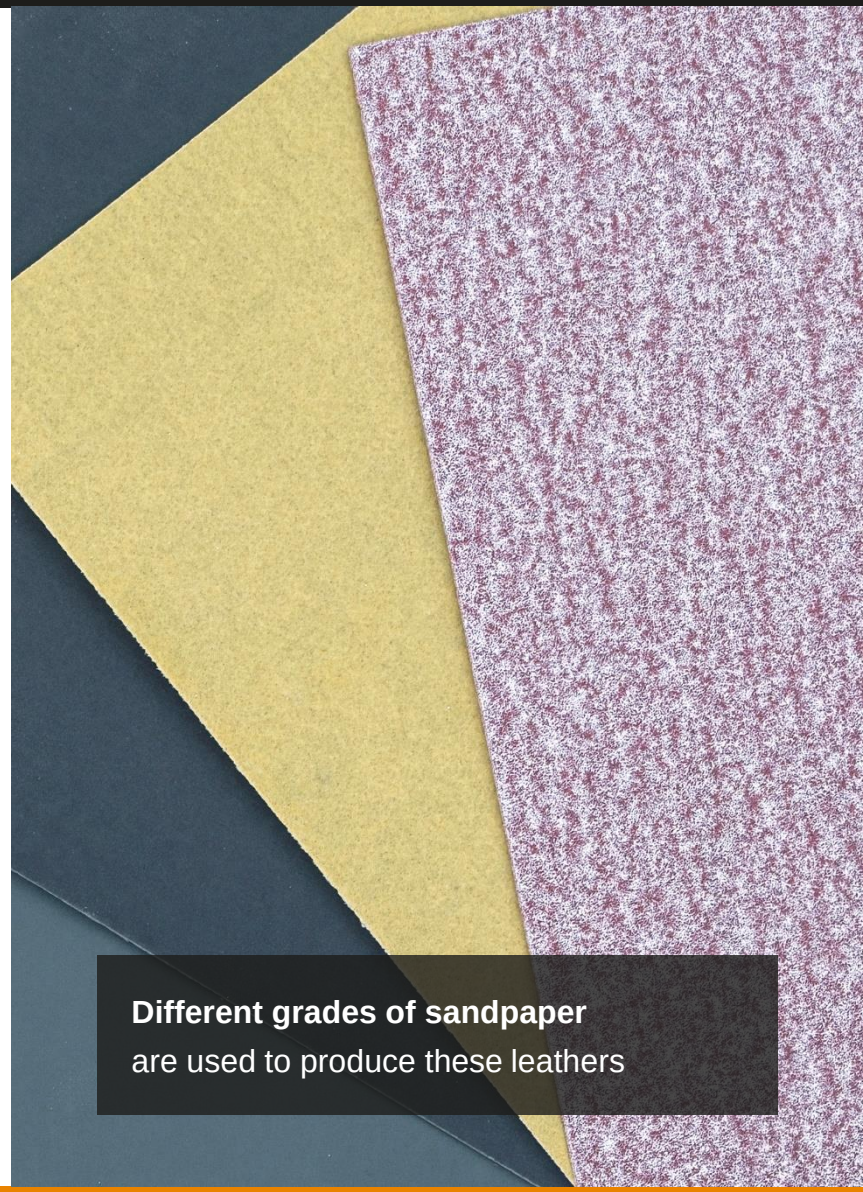




MAIN TYPES OF LEATHER

Full Grain	Leather with the grain (surface) intact
Snuffed Grain*	Leather with light sanding on the surface to uniformize and reduce defects
Corrected Grain*	Leather with heavier sanding on the surface to reduce defects It can be finished, oiled/waxed or impregnated to make box leather
Nubuck	Type of corrected grain leather with deep coarse buffing that has no finish but can be oiled/waxed
Split	Leather from the lower split part of the leather, sanded Can be unfinished, finished or oiled/waxed
Suede	Leather from the lower split part of the leather, sanded, not finished Can have wax/oils or other superficial treatments
PU Split	Leather from the lower split part of the hide coated with a polyurethane (PU) film less than 0.15 mm thick

*** Top Grain** leathers can have **Snuffed** or **Corrected Grain**



Different grades of sandpaper
are used to produce these leathers

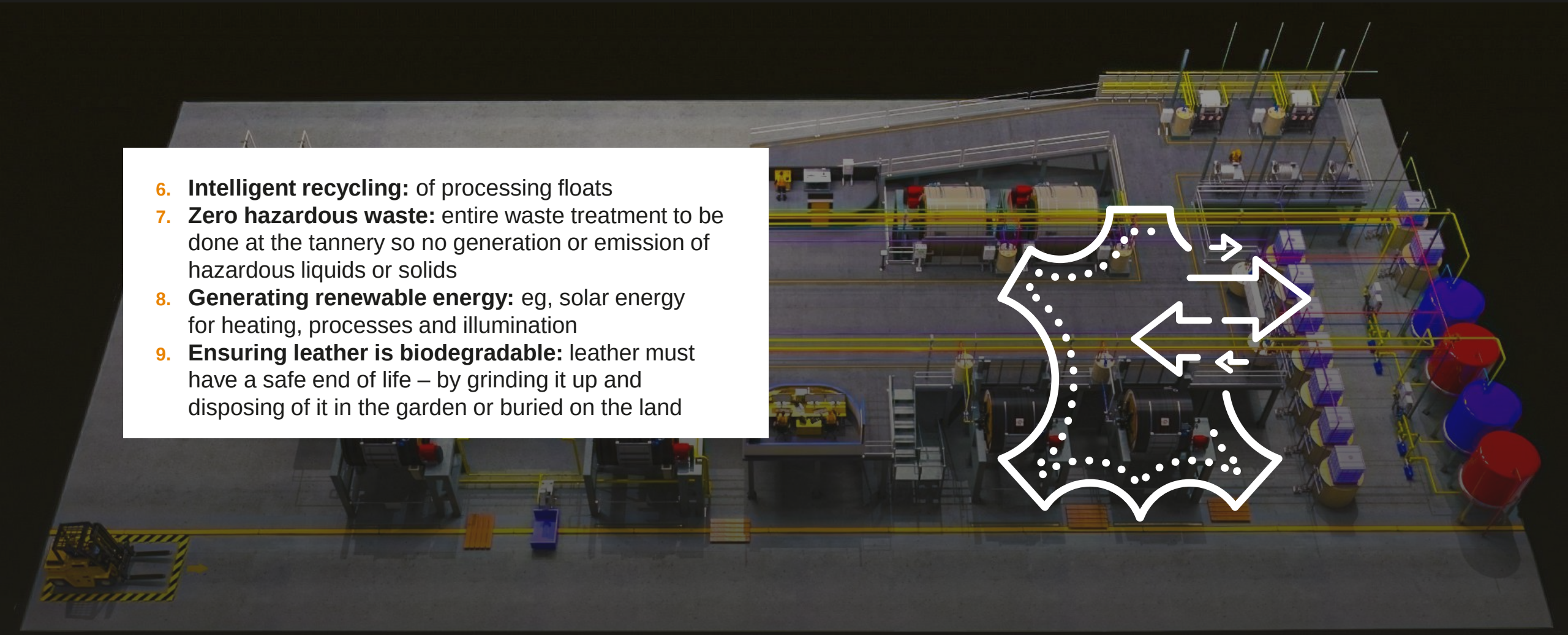
WHAT WILL COW HIDE TANNERIES BE LIKE IN THE FUTURE?

1. **Well-sourced hides:** traced, with provenance from good farms following high standards of animal welfare
2. **Fully used by-products**: separate by-products at earliest possible stage (green hide processing, hair safe, etc) and thus lower effluent load (COD) and improve value and use of by-products
3. **Zero gas emissions:** from sulfide and H2S used during the unhairing process
4. **Well-sourced chemicals:** ideally from renewable sources; safe for workers, consumers and the environment; intrinsically biodegradable
5. **Automated processes:** a) reducing manual handling of hides and chemicals b) increasing chemical uptake and efficiency



WHAT WILL COW HIDE TANNERIES BE LIKE IN THE FUTURE?

6. **Intelligent recycling:** of processing floats
7. **Zero hazardous waste:** entire waste treatment to be done at the tannery so no generation or emission of hazardous liquids or solids
8. **Generating renewable energy:** eg, solar energy for heating, processes and illumination
9. **Ensuring leather is biodegradable:** leather must have a safe end of life – by grinding it up and disposing of it in the garden or buried on the land



PHOTOS, DIAGRAMS AND LEATHER INDUSTRY CREDITS

- 4 Leather Techniques Through the Ages, BASF, publication B336, 1966 and Collagen structure function…, Bioengineering, 8, 3, 2021
- 11 USHSLA (LHCA), Washington, DC, August 2014
- 13 Heller Leder
- 14 Durli Couros
- 16 Giovanni Carpanese
- 21, 22 Heller Leder
- 23 ITALPROGETTI, Durli Couros and World Leather
- 24 HUNI
- 27 Dr. Mariano Mecenero
- 30, 31, 32 Andreas Rhein
- 33 Sepiciler Deri
- 34 SILVATEAM and TANAC
- 35 SILVATEAM
- 36 ITALPROGETTI
- 38 Heller Leder
- 40 ASSOMAC
- 41 Heller Leder
- 45 ITALPROGETTI, JBS
- 48 Sepiciler Deri, GEMATA, Heller Leder, JBS
- 49 World Leather, Heller Leder, JBS
- 55, 56, 57 GEMATA
- 58 JBS, Young Il Leather Co, Heller Leder, Coindu Automotive Interiors China
- 59 Simone Pucci
- 60, 61 GSC
- 62 Simone Pucci
- 63, 64 ATC
- 74 LECTRA
- 75, 76 GSC
- 77 HUNI
- 78 ITALPROGETTI
- 83, 84 W2O Environment
- 85 Jörg Rausch
- 87 Durli Couros
- 88 HUNI
- 8, 15, 16, 18, 19, 20, 30, 40,47, 59, 60, 61, 76, 76, 86, 89 and photo editing by Dr. Luis Zugno
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