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. Chemistry and tanning processes have continued to evolve down through the generations.
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

**Cow hide composition**

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>33%</td>
</tr>
<tr>
<td>Fats</td>
<td>2-6%</td>
</tr>
<tr>
<td>Minerals</td>
<td>0.5%</td>
</tr>
<tr>
<td>Water</td>
<td>65%</td>
</tr>
</tbody>
</table>
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
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 m² or 50 ft².
NOT ALL COW HIDES ARE THE SAME

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AGE</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>FEED</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>BREEDS</strong></td>
<td>Breed determines the size, thickness, fiber structure, shape and hair type of the hide.</td>
</tr>
<tr>
<td><strong>SEX</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>CLIMATE CONDITIONS</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>BRANDS</strong></td>
<td>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.</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>VOLUME MILLIONS</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
</tr>
</tbody>
</table>
| 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%  
• Mostly full grain | 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 |
## Guide to Packer Hide Selections with Estimated Weights

<table>
<thead>
<tr>
<th>Selection</th>
<th>Type</th>
<th>Description</th>
<th>Trimmed &amp; Fleshed</th>
<th>Curved Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Heavy Native</td>
<td>Steers and heifers</td>
<td>Free of brands</td>
<td>64 up</td>
<td></td>
</tr>
<tr>
<td>Heavy Native</td>
<td></td>
<td></td>
<td>47 up</td>
<td></td>
</tr>
<tr>
<td>Extra Heavy Butt-branded</td>
<td>Steers and heifers</td>
<td>Branded one or more times back of break in flank</td>
<td>64 up</td>
<td></td>
</tr>
<tr>
<td>Butt Branded</td>
<td></td>
<td></td>
<td>47 up</td>
<td></td>
</tr>
<tr>
<td>Extra Heavy Colorado (Side branded)</td>
<td>Steers and heifers</td>
<td>Branded one or more times forward of break in flank</td>
<td>64 up</td>
<td></td>
</tr>
<tr>
<td>Colorado Branded</td>
<td></td>
<td></td>
<td>47 up</td>
<td></td>
</tr>
<tr>
<td>Extra Heavy Branded</td>
<td>Steers and heifers</td>
<td>Branded one or more times</td>
<td>67 up</td>
<td></td>
</tr>
<tr>
<td>Branded</td>
<td></td>
<td></td>
<td>47 up</td>
<td></td>
</tr>
<tr>
<td>Extra Heavy Texas</td>
<td>Steers and heifers</td>
<td>Texas Panhandle Area origin</td>
<td>64 up</td>
<td></td>
</tr>
<tr>
<td>Heavy Texas</td>
<td></td>
<td></td>
<td>47 up</td>
<td></td>
</tr>
<tr>
<td>Native – Light</td>
<td>Steers and heifers</td>
<td>Free of brands</td>
<td>55 down</td>
<td></td>
</tr>
<tr>
<td>Texas – Light</td>
<td>Steers and heifers</td>
<td>Mix of Texas</td>
<td>55 down</td>
<td></td>
</tr>
<tr>
<td>Branded – Light</td>
<td>Steers and heifers</td>
<td>Branded one or more times</td>
<td>55 down</td>
<td></td>
</tr>
<tr>
<td>Heavy Native Cows (Dairy)</td>
<td>Milk breed cows</td>
<td>Free of brands</td>
<td>45 up</td>
<td></td>
</tr>
<tr>
<td>Native Cows (Dairy) Light</td>
<td></td>
<td></td>
<td>45 down</td>
<td></td>
</tr>
<tr>
<td>Heavy Native Cows (Beef)</td>
<td>Beef breed cows</td>
<td>Free of brands</td>
<td>45 up</td>
<td></td>
</tr>
<tr>
<td>Native Cows (Beef) Light</td>
<td></td>
<td></td>
<td>45 down</td>
<td></td>
</tr>
<tr>
<td>Heavy Branded Cows (Beef)</td>
<td>Beef breed cows</td>
<td>Branded one or more times</td>
<td>45 up</td>
<td></td>
</tr>
<tr>
<td>Branded Cows Light (Beef)</td>
<td></td>
<td></td>
<td>45 down</td>
<td></td>
</tr>
</tbody>
</table>

### Weight Range

<table>
<thead>
<tr>
<th>NET WEIGHT RANGE</th>
<th>POUNDS (lb.) CURED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trimmed &amp; Fleshed</td>
<td></td>
</tr>
</tbody>
</table>

### United States Cow Hide Classification

- Extra Heavy Native: Steers and heifers, free of brands
- Heavy Native: Steers and heifers, free of brands
- Extra Heavy Butt-branded: Steers and heifers, branded one or more times back of break in flank
- Butt Branded: Steers and heifers, branded one or more times back of break in flank
- Extra Heavy Colorado (Side branded): Steers and heifers, branded one or more times forward of break in flank
- Colorado Branded: Steers and heifers, branded one or more times forward of break in flank
- Extra Heavy Branded: Steers and heifers, branded one or more times
- Branded: Steers and heifers, branded one or more times
- Extra Heavy Texas: Steers and heifers, Texas Panhandle Area origin
- Heavy Texas: Steers and heifers, Texas Panhandle Area origin
- Native – Light: Steers and heifers, free of brands
- Texas – Light: Steers and heifers, mix of Texas
- Branded – Light: Steers and heifers, branded one or more times
- Heavy Native Cows (Dairy): Milk breed cows, free of brands
- Native Cows (Dairy) Light: Milk breed cows, free of brands
- Heavy Native Cows (Beef): Beef breed cows, free of brands
- Native Cows (Beef) Light: Beef breed cows, free of brands
- Heavy Branded Cows (Beef): Beef breed cows, branded one or more times
- Branded Cows Light (Beef): Beef breed cows, branded one or more times
- Native Bull: Males, free of brands
- Branded Bull: Males, branded one or more times
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.

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

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.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Area</th>
<th>Weight</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extra Heavy</strong></td>
<td>Average area 52-56 ft², Average weight 28-30 kg</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Standard</strong></td>
<td>Average area 48-52 ft², Average weight 24-26 kg</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td><strong>TR I</strong></td>
<td>Average area 52-56 ft², Average weight 28-30 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TR II</strong></td>
<td>Average area 46-48 ft², Average weight 22-24 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TR III</strong></td>
<td>Average area 46-48 ft², Average weight 21-23 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TR IV</strong></td>
<td>Average area 46-48 ft², Average weight 20-22 kg</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Economic</strong></td>
<td>Average area 46-48 ft², Average weight 18-20 kg</td>
<td></td>
<td>Leathers for low grade upholstery and shoes with a heavy finish eg; safety shoes.</td>
</tr>
<tr>
<td><strong>TR V</strong></td>
<td>Average area 46-48 ft², Average weight 18-20 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reject</strong></td>
<td>Average area 46-48 ft², Average weight 18-20 kg</td>
<td></td>
<td>Leathers used for shoes with a heavy finish, such as safety shoes and safety items.</td>
</tr>
</tbody>
</table>
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

- Neck wrinkles
- Insect bites
- Scratches
- Veins
- Belly drawn
- Manure damage
- Brand
- Belly drawn
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.
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
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

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw hide</td>
<td>fresh, brine cured or salted hide, wet</td>
</tr>
<tr>
<td>Tanning</td>
<td>hide stabilization by chrome, white tannage or vegetable, wet</td>
</tr>
<tr>
<td>Crust</td>
<td>leather processed after tanning to give color and properties, dried</td>
</tr>
<tr>
<td>Finishing</td>
<td>crust with coatings to change its properties; mechanical operations to change surface appearance</td>
</tr>
</tbody>
</table>
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
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.
- 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

FULL SUBSTANCE

Soaking ➔ Unhairing ➔ Fleshing ➔ Deliming ➔ Pickling ➔ Tanning ➔ Wringing

LIME SPLIT

Splitting ➔ Deliming ➔ Pickling ➔ Tanning ➔ Wringing
## TYPICAL BEAMHOUSE (RAW TO TANNING) PROCESS

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

<table>
<thead>
<tr>
<th>Process</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soaking</td>
<td><em>Soda ash, magnesium oxide, enzymes, bactericides, wetting agents and emulsifiers</em></td>
</tr>
<tr>
<td>Unhairing</td>
<td><em>Sodium sulfide, sodium sulfhydrate, lime, enzymes, degreasers, emulsifiers, penetrants</em></td>
</tr>
<tr>
<td>Fleshing</td>
<td><em>Mechanical process only</em></td>
</tr>
<tr>
<td>Deliming</td>
<td><em>Ammonium sulfate or chloride, organic acids, carbon dioxide, acid salts, degreasers and enzymes</em></td>
</tr>
<tr>
<td>Pickling</td>
<td><em>Common salt, organic acids, sulfuric acid</em></td>
</tr>
<tr>
<td>Tanning</td>
<td><em>Mostly chrome (III) sulfate, tannins, syntans and glutaraldehyde. Fungicides are added here to protect leather against mold</em></td>
</tr>
<tr>
<td>Set out</td>
<td><em>Mechanical process to adjust leather moisture to 50% - 60%</em></td>
</tr>
</tbody>
</table>
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 uses mostly chrome (III) sulfate – the worldwide industry standard is a soluble green powder that contains 26% Cr₂O₃. 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.
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 (m² or ft²)
- 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 m² to 5 m² (38 ft² to 54 ft²)
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 its 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

<table>
<thead>
<tr>
<th>Plant part used</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chestnut (Castanea sativa)</td>
<td>Italy (and across Europe)</td>
</tr>
<tr>
<td>Mimosa (Acacia mearnsii)</td>
<td>Brazil, South Africa</td>
</tr>
<tr>
<td>Quebracho (Schinopsis lorentzii)</td>
<td>Argentina, Bolivia, Paraguay</td>
</tr>
<tr>
<td>Tara (Caesalpinia spinosa)</td>
<td>Peru and Bolivia</td>
</tr>
</tbody>
</table>
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.
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.
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.
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

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

<table>
<thead>
<tr>
<th>LETTER</th>
<th>OUNCE</th>
<th>INCHES</th>
<th>MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/64”</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>2</td>
<td>1/32”</td>
<td>0.80</td>
</tr>
<tr>
<td>LM</td>
<td>3</td>
<td>3/64”</td>
<td>1.20</td>
</tr>
<tr>
<td>HM</td>
<td>4</td>
<td>1/16”</td>
<td>1.60</td>
</tr>
<tr>
<td>HH</td>
<td>5</td>
<td>5/64”</td>
<td>2.00</td>
</tr>
<tr>
<td>HHH</td>
<td>6</td>
<td>3/32”</td>
<td>2.40</td>
</tr>
</tbody>
</table>
TYPICAL FLOW DIAGRAM OF WET END

LEATHER
- Splitting
- Shaving

CRUST
- Drying
- Finishing

Wet end
- Neutralization
- Retanning
- Coloring
- Fatliquoring

Lime split leathers start here
<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splitting</td>
<td>Mechanical operation to slice the leather into grain and split parts</td>
</tr>
<tr>
<td>Shaving</td>
<td>Mechanical operation to uniformize the thickness of the leather</td>
</tr>
<tr>
<td>Neutralization</td>
<td>Chemical step to reduce the leather acidity in preparation for retanning</td>
</tr>
<tr>
<td>Retanning</td>
<td>Natural and synthetic chemicals are added to improve/add leather properties</td>
</tr>
<tr>
<td>Dyeing</td>
<td>Dyes are added to give color to the leather</td>
</tr>
<tr>
<td>Fatliquoring</td>
<td>Oils and waxes are added for softening and lubrication</td>
</tr>
<tr>
<td>Drying</td>
<td>Natural or forced drying, these days using advanced machinery</td>
</tr>
<tr>
<td>Finishing</td>
<td>This is the process of converting the crust leather to finished leather</td>
</tr>
</tbody>
</table>
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.

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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
Wring 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
<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auxiliaries</strong></td>
<td>Surfactants, oil and wax emulsions, solvents, silicones. In some leathers. Oils and waxes can be used alone, without binders</td>
</tr>
<tr>
<td><strong>Fillers</strong></td>
<td>Clays, silicas, organic polymer particles for filling or dulling</td>
</tr>
<tr>
<td><strong>Pigments</strong></td>
<td>Organic and inorganic pigment dispersions, finely ground</td>
</tr>
<tr>
<td><strong>Dyes</strong></td>
<td>Metal complex dye solutions</td>
</tr>
<tr>
<td><strong>Binders</strong></td>
<td>Acrylic and PU (polyurethane) emulsions producing soft to hard films, natural proteins (e.g., casein) and modified natural cellulose</td>
</tr>
</tbody>
</table>
FINISHING

THE MAIN STEPS

**BUFFING** (Sanding)

Like wood, leather can be sanded with different grades of sandpaper to 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.
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.
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.
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.

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

**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.

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

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

**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

The finish coatings can be summarized in four types:

- **Aniline**: dye can be applied alone or with transparent finish, can be applied on the top of oils and waxes. Some pigments are added to the coating, reducing the transparency and uniformizing the leather. Most expensive leathers are in this category.

- **Semi-aniline**: small amounts of pigments are added to the coating, reducing the transparency and uniformizing the leather. The leather pores are still visible, and quality is still high.

- **Semi-pigmented**: more pigments are added to the coatings. The leather pores are still visible, and quality is still high.

- **Pigmented**: when highly pigmented coats are applied to the leather and pores are not visible. Many automotive leathers are in this category.

**DIFFERENCE BETWEEN DYE AND PIGMENT**

- **Dye**: (soluble in water or solvent, transparent)
- **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

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANILINE</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>SEMI-ANILINE</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>SEMI-PIGMENTED</strong></td>
<td>More pigments are added to the coatings to improve the uniformity. The leather pores are less visible, and quality is still high.</td>
</tr>
<tr>
<td><strong>PIGMENTED</strong></td>
<td>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.</td>
</tr>
</tbody>
</table>

**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.


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$_2$O$_3$ (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)
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.
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.
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).
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.
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.
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:

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

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

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

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.

Pull up leathers have a different color when folded (pull up color). Surface and pull up color need to match.
MANAGING CHEMICAL INPUT

Leather is made by tanning animal hides using water and chemicals (e.g., 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

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>MAIN PARAMETERS THAT DEFINE THE QUALITY AND PRICE</th>
<th>UNITS (HOW IT IS SOLD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw hide</td>
<td>Type*, size, grade, origin**, weight range, curing method***</td>
<td>Piece, weight (lb. or kg), ft², m²</td>
</tr>
<tr>
<td>Wet blue</td>
<td>Type*, size, grade, thickness</td>
<td>Piece, ft², m²</td>
</tr>
<tr>
<td>Crust</td>
<td>Grade, thickness, color</td>
<td>ft², m²</td>
</tr>
<tr>
<td>Finished</td>
<td>Grade, finish type, thickness, color, cutting area</td>
<td>ft², m²</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>CONVERSION UNITS</th>
<th>CONVERSION UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ft²</td>
<td>0.0929 m²</td>
</tr>
<tr>
<td>10.764 ft²</td>
<td>1 m²</td>
</tr>
<tr>
<td>1 lb.</td>
<td>0.4536 kg</td>
</tr>
<tr>
<td>2.2046 lb.</td>
<td>1 kg</td>
</tr>
</tbody>
</table>
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
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*

<table>
<thead>
<tr>
<th>Material</th>
<th>Time in Years</th>
<th>Material</th>
<th>Time in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>Forever</td>
<td>Acrylic</td>
<td>10 to 100</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>+ 1,000</td>
<td>Leather</td>
<td>0.05 to 45</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>+ 1,000</td>
<td>Paper</td>
<td>2 to 5 months</td>
</tr>
<tr>
<td>PE Low density</td>
<td>100 to 1,000</td>
<td>Cotton</td>
<td>1 to 5 months</td>
</tr>
<tr>
<td>Polycarbonate</td>
<td>100 to 500</td>
<td>Banana peel</td>
<td>10 days</td>
</tr>
<tr>
<td>Polyester and PU</td>
<td>20 to 200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 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**
- **Recycling process chemicals and water**
- **Reducing energy requirements**
- **Reducing emissions and sludge generation**
- **Increasing efficiency of treatments**

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
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

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

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

Different grades of sandpaper are used to produce these leathers.
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?
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

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- 34 SILVATEAM and TANAC
- 35 SILVATEAM
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- 60, 61 GSC
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- 63, 64 ATC
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- 83, 84 W2O Environment
- 85 Jörg Rausch
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