Leather for Pipe Organs

**Summary of "Aging of Organ Leather" by H. V. Piltingsrud & J. J. Tancous.
Published by the International Society of Organ Builders (1992).**

The reason for this study: Early failure of leather in pipe organs in the second half of 20th century.

The publication was intended to give the organ builder, restorer and maintenance person an understanding of what leather is, how certain modern leather are produced, why the longevity of leather used between approximately 1940-1990 had been unpredictable and often unacceptably short, and how to test and select leathers likely to have long service lives. It describes a test method for indicating the relative longevity of particular leather samples and identifies types of leather processing that should produce long-lasting leathers. Data presented indicate that there are modern tanning methods that can produce leathers suitable for nearly all uses in pipe organs and that have long projected lifetimes (likely to exceed sixty years). Those leathers have full chrome-tanning.

Some organ builders (ones that plan to be around for the indefinite future) have indicated that their reputation is tied partially to the longevity of leather used in their organs.

Introduction

Throughout the history of pipe organ building, leather has been widely used wherever a flexible, air-tight material was required. Applications such as pneumatic actuators for windchest mechanisms such as pneumatic pouches, pressure regulators, reservoir bellows hinges and gussets, mechanical linkages, gaskets and other elements of windchest and pipe construction have traditionally been made out of leather.

Included in the introduction is a general description of the tanning of leather, leather structure, examples of many kinds of leather and their uses, and various types of finishes applied to leather.

We think is helpful, in this summary, to show what the underlying structure of leather is that gives it many of its properties. The basic material that gives a hide (untanned animal skin) and leather (the tanned/processed hide) its structure and strength is collagen. Different forms of it also make up bone and other components of an animal. Its smallest units are tiny fibers made up of organic chemical building blocks that form collagen strands that make up a network of bundles of threads. These bundles are formed into a matrix much like a woven cloth. Photo I. shows the thread-like bundle of collagen fibers. Photo II. shows a more cloth-like interweaving of such fiber bundles.

Photo I.

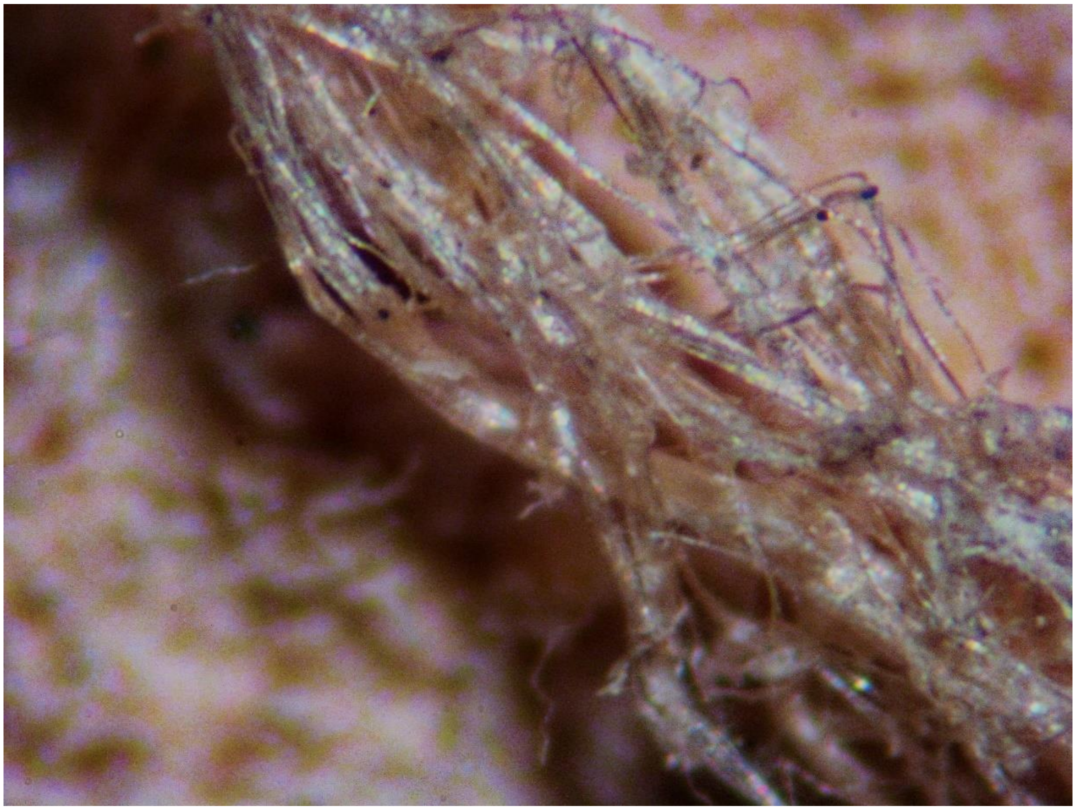
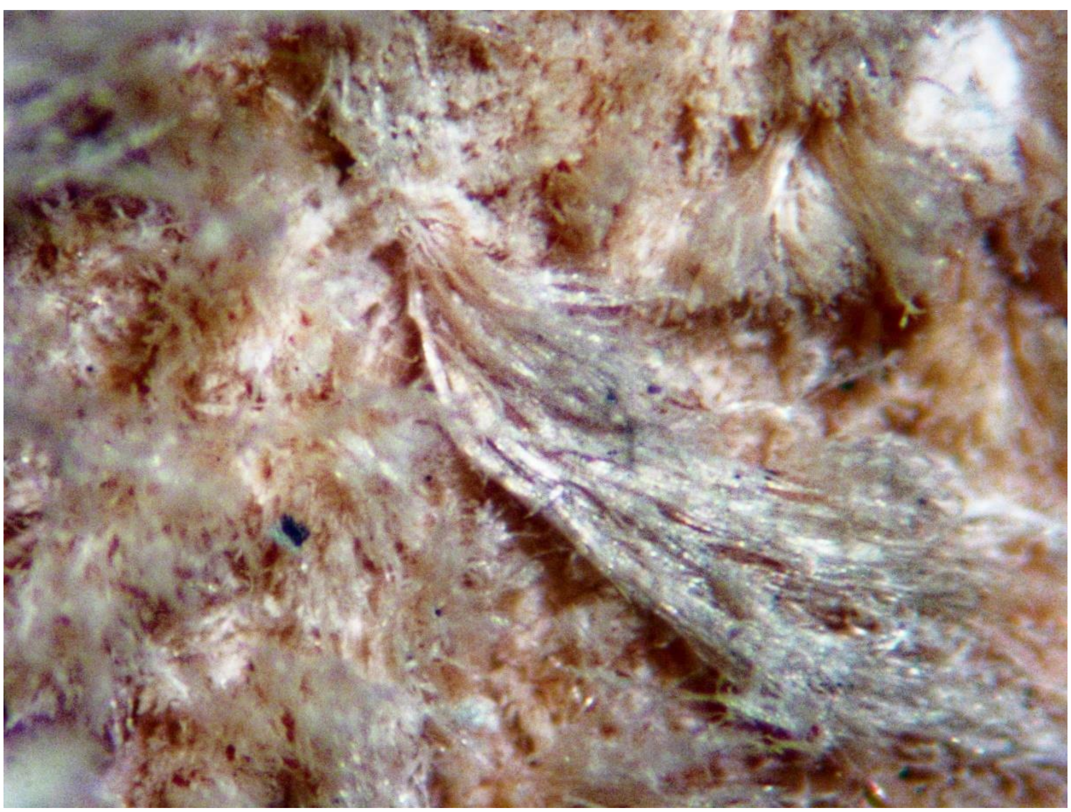


Photo II.



The tanning of leather consists of several basic steps, beginning with hides of animals chosen for their special qualities related to the leather desired. The hides are processed to prepare them for the addition of tanning materials. The tanning materials have chemical qualities that stabilize the hide material, usually with chemical bonding to the collagen material and often with chemical interlinking of the collagen fibers, one to another. The tanning process usually makes the resulting leather stronger than the hide material and much more resistant to change from chemical or bacterial attack.

With the arrival of the industrial revolution, the burning of coal increased dramatically, releasing the gas, sulfur dioxide, and it became a major air pollutant of the late 19th and part of the 20th centuries. Sulfur dioxide was identified in the mid-19th century as the likely contributor to the early failure of leather, particularly in applications requiring a long life, such as upholstery and bookbinding.

This was followed by a description of past efforts of leather chemists develop tests to identify long-lasting leather for various applications. They also attempted to identify tanning methods associated with leathers resistant to deterioration.

One of the leather chemists mentioned in this paper is A. Cheshire. He presented particularly detailed chemistry models for the complex way that leather deteriorates resulting from sulfur dioxide in the air. This process involved chemistry on a microscopic level with the tiny fiber strands that join to make up collagen. Cheshire went on to develop a testing method that exposed leathers to sulfur dioxide and oxygen in a controlled way. His test produced results that corresponded well to the deterioration of leather samples that were exposed to atmospheres containing sulfur dioxide over long periods of time.

H. V. Piltingsrud and J. J. Tancous developed a test (sulfur dioxide test) for the relative longevity of leathers as indicated by their resistance to deterioration produced by the test. It was published in 1987, using a modification of a test developed by A. Cheshire. That test method, which is presented in this paper, was updated in a publication by ASTM International “Practice for Accelerated Aging of Leather” ASTM D8137-18. This features a detailed procedure for conducting the sulfur dioxide test. The procedures feature more modern equipment for the test and the use of a lower exposure temperature (60 degrees C). The analysis of data has also been improved.

Twenty samples of leather were tested in the study described in this publication. They included leathers available to organ builders at that time (1980’s) as well as samples taken from historic instruments, going back to the 19th century. Very few of the leathers tested had known tanning methods, and since they were produced by commercial tanneries one could not be certain of exactly how they were tanned. The test results indicated most leathers that had significant chrome content (a common tanning agent) had reasonable durability. The chrome content was measured by taking a known quantity (mass) of leather and by chemical methods extracting the chrome as chromium oxide. That was weighed and listed as a percent of the original mass of the leather sample.

Conclusions

The suitability of a leather for pneumatic pouch motors depends upon several factors including its thickness, its flexibility, its initial tensile strength and its rate of loss of tensile strength as a function of time. Other factors may include its gluing properties, porosity, and pinhole content.

It appears that some older vegetable-tanned (a category of tanning agents), tan pneumatic leathers were very durable; however, the exact reason for this can only be speculated on, based on the work of Cheshire. It is likely they received vegetable tanning that left significant deposits of a chemical, calcium oxalate, in the leather. E. M. Skinner commented that he thought "Sumac skiver valve" was the most suitable leather for primary pneumatic pouches. The leather he used proved to be very durable. It is likely that leather was vegetable-tanned using sumac tanning agents. That particular tanning agent has very low availability in the present time. Nearly all vegetable-tanned leathers are presently in very low supply, and likely do not have the properties desired for organ applications.

Some tan pneumatic pouch leathers that were in use in the 1980's may have been a combination of vegetable and chrome tanning. Their durability ranged from bad to good, and appeared influenced by the concentration of chrome in the leather. Combinations of tanning agents can produce complicated results when considering longevity.

The chrome-tanned hair sheep leathers (a kind of sheep) from the 1980's that were tested appeared to be quite durable and had acceptable tensile strengths. The "white zickel" leather evaluated, was exceptionally strong and reasonably durable. However, there are no reliable sources for that leather and its tanning method was not documented (believed to contain zirconium).

Re-fatting materials are oil/fat-like materials intended to put some oils back into leather to replace those removed in tanning. The uses of stable re-fatting materials (re-fatting materials that keep their important qualities over an extended period of time) could be important in maintaining consistent mechanical qualities in a leather. **Leathers tanned using a modest amount of the most stable re-fatting material should experience a minimum of stiffening with time.**

Leathers intended for uses other than in pipe organs may contain excessive re-fatting materials. Rinsing leather in a solvent such as tetrachloroethylene (dry cleaning of leather) can remove a lot of oils, greases and waxes that may not be important to the function of the leather in pipe organs and could result in the stiffening and deterioration of leather with time. This process can also improve the leather's compatibility with the use of hide glue.

Adding oils and greases (petroleum jelly, specialty oils, etc.) to leather being installed or having been installed in pipe organs is likely to reduce the service life of the leather. The evaporation of components of the material and the oxidation of remaining residues may cause stiffening and contribute to the deterioration of the leather.

It appears that there is only one widely available leather suitable for pneumatic pouch applications. It is properly-processed full-chrome-tanned young hair sheep with greater than 2.0% chrome, measured as chromium oxide. In accordance with other studies, it would seem advantageous to have greater than 3.5% chrome content. Leathers for other applications in pipe organs requiring thicker leather or having other needed properties should be available having full-chrome tanning.

In order to achieve the longest possible service life it would be prudent for an organ builder to use a leather having as thick a leather as is compatible with its application. Also, it should have as high a starting tensile strength as possible, and a low loss of tensile strength

with time. All of that must be consistent with the proper function of the leather in the application intended and with some allowance for minor changes in the leather with time.

The sulfur dioxide test should be useful for ranking relative durability of leathers of undocumented tanning and animal type. If it is certain the leather has been properly processed with full-chrome tanning (no pre-tanning or combination tanning with other tanning agents), an analysis for chrome content could be sufficient. **That analysis must be done on the final product after any thinning of the leather and any removal of chrome from the grain layer of the leather.** Since it is nearly impossible to know the exact processing of commercially produced leathers, additional tests are prudent to understand the potential durability of leathers.

Nearly all of the conclusions presented in the 1992 publication continue to be valid. Recent work presented in "Atmospheric Pollution and the Deterioration of Leather" shows that the present atmospheric concentration of nitrogen dioxide is significant in the long-term deterioration of leather. The exposure of test leathers to nitrogen dioxide results in some differences in the implied durability of some leathers when compared to sulfur dioxide exposures. That is particularly the case for vegetable-tanned leathers. If one only considers testing the durability of chrome-tanned leathers, the results are similar for both sulfur dioxide and nitrogen dioxide. **That publication recommends some additional tests for indicating the longevity of chrome-tanned leather.**