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COMPARATIVE WEAR OF CHROME-TANNED, VEGETABLE-TANNED, AND RETANNED SOLE LEATHER

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ABSTRACT

The results of actual service tests of commercial leathers show that chrome-tanned sole leather wears longer than vegetable-tanned leather, and that the durabilities of retanned or of combination-tanned leathers lie between the two.

CONTENTS

I. INTRODUCTION

Tanning with salts of chromium has been applied to heavy hides for the production of sole leather in the belief that a product could be obtained which would possess greater resistance to wear than vegetable-tanned leather. Previous work done by this Bureau [1] showed that this belief was justified and that natural chrome-tanned sole leather wore about twice as long as vegetable-tanned sole leather. The chief disadvantage was found to be its loose structure, which accounted for its lack of firmness and its relatively low water resistance.

The presentation of these results was followed by a marked activity on the part of tanners in the preparation of sole leathers tanned, in part, with salts of chromium. Numerous leathers appeared which were produced by various combinations of the chrome- and vegetable-tanning processes, together with the use of different fillers. All of these leathers were prepared with the object of approaching the firmness and water resistance characteristic of vegetable-tanned leather and utilizing, so far as possible, the increased durability shown to be inherent in chrome leather.

The logical result of this situation was a demand for information by which the success of the new processes could be measured. Consequently, at the solicitation of many interested tanners and in view of the expressed interest of various departments of the Government,

[1] R. C. Bowker and M. N. V. Geib, *Comparative durability of chrome- and vegetable-tanned sole leathers*, Tech. Pap. BS **19**, 267 (1924–25)T.

TABLE 1.—*Chemical analyses of leathers*

FC=Filled chrome.
NC=Natural chrome.
HRC=Heavy retanned chrome.
LRC=Light retanned chrome.
MRC=Medium retanned chrome.
C=Combination tanned.
FV=Flexible vegetable.
V=Vegetable.

Series	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Leather	FC	NC	FC	NC	NC	NC	HRC	LRC	MRC	C	NC	FC	LRC	C	FC	LRC	HRC	HRC	HRC	FV	FV	FV
Constituent:																						
Water-solubles	15.18	5.85	12.98	No test	4.64	1.68	23.12	8.36	3.95	21.83	5.37	16.40	21.22	8.90	8.15	7.47	23.00	4.88	23.20	20.30	25.20	28.80
Hide substance	34.75	74.20	34.61	do	80.55	88.15	41.68	63.90	35.40	40.70	75.80	33.25	40.50	43.30	34.80	47.10	37.50	40.60	39.60	41.10	33.70	33.70
Grease (petroleum-ether extract)	22.83	2.73	22.71	do	1.79	1.00	5.34	11.26	37.21	5.46	2.14	21.22	7.99	13.70	24.30	30.20	8.52	15.84	8.28	5.35	15.35	9.00
Insoluble ash	19.47	7.90		do		6.73	1.52	3.30	2.00	2.94	4.47	17.40	20.80	3.74	20.90	2.68	2.18	3.29	1.97	.20	.28	.23
Combined tannin [1]				do			28.34		21.43	29.07			9.49	30.36		12.55	28.80	35.39	26.95	33.05	25.47	28.27
Total							100.00		100.00	100.00			100.00	100.00		100.00	100.00	100.00	100.00	100.00	100.00	100.00
Degree of tannage [2]				No test			68.10		60.70	71.50	16.20		23.40	70.20		26.60	76.80	87.20	68.00	80.50	75.70	84.00
Glucose	6.03		5.54	do			2.40			5.98		5.12	7.85				.90		.90		2.77	
Epsom salts				do			6.02			7.96	1.10	7.03	8.10		.48		1.00		3.30	1.08	.66	1.09
Total ash	20.18	9.87	23.19	do	8.00	6.75	4.72		2.69	8.29	6.45	25.95	27.10	5.54		6.72	5.45	4.16	3.69	2.26	1.18	4.04
Chrome (Cr_2O_3)	5.08	7.22	4.06	do	5.24	5.55	1.47	2.52	1.89	2.43	4.04	3.38	4.18	2.34	2.23	2.48	1.17	2.76	1.27			
Barium ($BaSO_4$)				do								14.00	15.50									

Series	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Leather	V	V	V	V	FC	FC	V	V	V	V	V	LRC	MRC	V	V	V	V	V	V	V	V	V
Constituent:																						
Water-solubles	25.91	29.85	28.45	31.88	No test	1.60	31.63	No test	37.50	33.85	28.70	21.22	22.10									
Hide substance	41.25	38.36	39.51	37.67	do	64.35	39.40	do	32.10	33.90	37.80	40.50	39.95									
Grease (petroleum-ether extract)	2.27	2.41	3.24	3.46	do	24.07	3.51	do	5.34	4.57	4.27	7.99	8.99									
Insoluble ash	.15	.20	.50	.42	do	6.04	.15	do	.23	.16	.28	20.80	15.08									
Combined tannin [1]	30.43	29.18	28.30	26.57	do		25.31	do	24.82	27.52	28.95	9.49	13.87									
Total	100.00	100.00	100.00	100.00			100.00		100.00	100.00	100.00	100.00	100.00									
Degree of tannage [2]	74.00	76.00	72.00	71.00	No test		64.30	No test	77.40	81.10	76.60	23.40	34.60									
Glucose	3.64	7.18	3.80	4.66	do		7.09	do	9.14	3.94	6.71	7.85	6.83									
Epsom salts	.50	2.17	3.42		do		5.58	do	6.07	5.94	2.59	8.10	7.24									
Total ash	.42	.90	2.76	2.80	do	6.08	1.99	do	4.58	3.94	2.14	27.10	22.75									
Chrome (Cr_2O_3)					do	6.23		do				4.18	2.76									
Barium ($BaSO_4$)					do			do				15.50	11.45									

Leather similar to 9V and 10V.

[1] Determined by difference.
[2] Ratio of combined tannin to hide substance.

a study was made to determine the comparative wear of these special leathers and vegetable-tanned leathers.

II. MATERIALS

All of the leathers used in this work were furnished by the tanners and were stated to be strictly commercial materials. Nine lots were vegetable tanned; 3 flexible vegetable; 3 natural chrome; 6 filled chrome; 5 light retanned chrome; 2 medium retanned chrome; 4 heavy retanned chrome; and 2 combination tanned; making a total of 34 lots of leather from 22 tanners. The chemical compositions of these leathers are shown in table 1.

III. TEST METHODS

There is no accepted laboratory method for measuring the durability of sole leather, nor is there any basic standard to which the durability of a given sample can be referred. Recourse was therefore had to the service test, whereby it is possible to get an indication of the comparative durabilities of any two leathers.

The procedure can best be described by following through one series—series 1, for example. This series consisted of 2 lots of leather, 1 vegetable tanned and 1 filled chrome, which were furnished by the same tanner. An equal number of right and left soles were cut from each lot. These soles were paired in such a way that the 2 soles in each pair came from the same location in the hides, and that half of the left soles were vegetable tanned and half of them chrome tanned. The soles were attached to shoes in the Bureau shop (a few were attached in a commercial shop), and were worn by members of the Bureau staff.

Each wearer was required to record the number of hours the shoes were worn, and to bring them in for examination at stated intervals. When one of the soles was found to be worn through, the pair was withdrawn from service. The durability of the worn sole was obtained from the time record kept by the wearer; that of the other sole was estimated from the measured loss of thickness.

In series 1 there were 28 pairs of soles. It was found that on the average the chrome sole would last 80.8 days, the vegetable sole 66.4 days. Since there was some difference in thickness between the original soles, this factor was eliminated by dividing the days worn by the original thickness, to get "days wear per iron".[2] This was found to be 10.1 for the chrome and 8.2 for the vegetable. On the basis of this test, therefore, it can be said with some degree of assurance that the particular filled-chrome leather examined was 23 percent more durable than the particular vegetable-tanned leather with which it was compared.

There were 22 such series in the present work, consisting of a total of 996 pairs of soles. The detailed test results are shown in table 2.

[2] One iron equals 1/48 inch.

TABLE 2.—*Results of wear tests*

Series	Description of leathers compared	Number of pairs of soles tested	Average thickness of soles (irons) [a]	Average days wear per sole	Percentage longer average wear per sole	Average days wear per iron [a]	Percentage longer average wear per iron [a]
1	Filled chrome	28	8.0	80.8	22	10.1	23
	Vegetable		8.1	66.4		8.2	
2 [b]	Natural chrome	33	8.0	192.1	72	23.9	111
	Vegetable		9.9	111.5		11.3	
3 [b]	Filled chrome	140	8.2	131.2	42	16.0	40
	Vegetable		8.1	92.2		11.4	
4	Natural chrome	63	9.4	195.0	113	20.9	115
	Vegetable		8.7	84.3		9.7	
5	Natural chrome	59	7.2	210.0	20	28.5	21
	Filled chrome		7.4	175.4		23.7	
6	Natural chrome	88	10.5	350.2	5	33.2	11
	Filled chrome		11.1	333.9		30.0	
7 [b]	Heavy retanned chrome	89	6.5	71.8	9	11.0	27
	Vegetable		7.6	66.3		8.7	
8	Light retanned chrome	19	8.0	156.0	39	19.4	76
	Vegetable		10.2	112.0		11.0	
9 [b]	Medium retanned chrome	131	10.3	160.0	48	15.5	48
	Vegetable		10.3	108.0		10.5	
10 [b]	Combination	99	9.4	121.0	22	13.0	31
	Vegetable		10.0	99.0		9.9	
11	Natural chrome	21	8.9	217.5	82	24.4	107
	Vegetable		10.1	119.2		11.8	
12 [b]	Filled chrome	39	10.2	145.3	17	14.2	13
	Light retanned chrome		9.8	123.2		12.6	
13 [b]	Light retanned chrome	43	8.8	135.5	9	15.3	12
	Medium retanned chrome		9.2	124.7		13.6	
14	Combination	19	12.3	262.0	35	21.3	18
	Vegetable		10.4	193.0		18.1	
15	Filled chrome	14	10.2	246.0	24	23.3	33
	Vegetable		10.9	198.0		17.5	
16	Light retanned chrome	18	11.3	251.0	70	23.0	67
	Vegetable		10.5	148.0		13.8	
17	Heavy retanned chrome	11	8.9	166.0	4	18.7	24
	Vegetable		10.8	160.0		14.2	
18	Heavy retanned chrome	14	10.7	157.0	1	14.7	4
	Vegetable		11.1	158.0		14.2	
19	Heavy retanned chrome	12	8.1	109.9	7	13.4	2
	Vegetable		8.8	117.0		13.1	
20	Flexible vegetable	17	7.5	74.0	16	9.9	5
	Vegetable		8.3	86.0		10.4	
21	Flexible vegetable	20	10.1	144.0	1	14.2	3
	Vegetable		10.6	146.0		13.8	
22	Flexible vegetable	19	10.2	193.0	4	18.9	6
	Vegetable		10.4	185.0		8	

[a] One iron equals 1/48 inch.
[b] From same hide.

IV. DISCUSSION AND SUMMARY

A comparison of the chemical compositions of the leathers with their relative durabilities indicates certain tendencies. In general, the greater the percentage of hide substance the greater the durability; the presence of chrome increases the durability; grease and insoluble ash have little effect; excessive amounts of water-soluble

materials seem to be deleterious. But these are all indications only—the relations are not sufficiently definite to permit expressing them as mathematical formulas.

For definite conclusions, recourse must be had to the names given to the leathers by the manufacturers. The appropriateness of the names can be checked to a certain extent by chemical analysis, and by visual observation, but it is evidently impossible to state definitely that a certain leather is "medium retanned chrome" and not "heavily retanned chrome."

Considering the durability of the vegetable leather as unity, the weighted averages taken from table 2 give the relative durabilities shown in table 3. It must be noted that all of the vegetable leathers used for comparison contained large amounts (over 20 percent) of water-soluble material.

TABLE 3.—*Relative durabilities of different types of sole leather*

[Durability of vegetable tanned leather = 1]

Types of leather	Series	Pairs of soles tested	Relative durability
Flexible vegetable	20, 21, 22	56	1.02
Heavy retanned chrome	7, 17, 18, 19	126	1.22
Combination	10, 14	118	1.29
Filled chrome	1, 3, 15	182	1.37
Medium retanned chrome	9	131	1.48
Light retanned chrome	8, 12, 13, 16	119	1.75
Chrome	2, 4, 5, 6, 11	264	1.77

The data in table 3 show that when the chrome- and vegetable-tanning processes are used either in combination or in succession, the durability of the resultant sole leather will be greater in proportion to the predominance of the chrome tannage.

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