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THE NEEDLE PENETROMETER: A NONDESTRUCTIVE DEVICE FOR MEASURING LEATHER STRENGTH*

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ABSTRACT

Abnormal weakness in leather is usually associated with a corresponding abnormality in fiber structure. Extreme weakness in certain Hereford hides is attributed specifically to the vertical fiber defect. Measurement of the resistance to needle penetration was found to reflect these structural differences and thereby to distinguish between weak and strong leathers. A bench-scale penetrometer device was applied to a variety of crust and finished leather specimens. Results were compared with data from a number of standard physical tests on the same materials to evaluate the potential usefulness of the new procedure.

Good correlation was established with the ball burst tests from a tannery trial lot and from a mixed set representing 125 sides. Close relationships with the tensile and slit tear strength tests were also shown, but correlations with extension or elongation tests were very low or negative. Comparisons involving steer, kip, and calf leathers brought out the importance of evaluating these maturity classes as separate groups rather than composite mixtures and of considering the possible influence of finishing. It is felt that the ERRL penetrometer is an acceptable new type of strength test with the special practical advantage of being essentially nondestructive.

INTRODUCTION

Weakness in properly processed side leathers made from certain types of well-cured cattlehides is a serious problem to the industry in many parts of the world. An extreme degree of weakness that is typically localized in the butt area of Hereford hides is often referred to as "pulpy butt" in this country. The term "vertical fiber" used by Amos (1), who first described the defect, is more appropriate to characterize the abnormal nature of the internal structure. In defective areas the corium fibers are arranged perpendicular to the surface in a loose, poorly interwoven pattern instead of in the normally compact, random network.

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A recent paper from this Laboratory (2) described an attempt to differentiate between normal and abnormal fiber structure in the butt area of cured hides by means of a needle penetration procedure. An experimental penetrometer was developed and tested for this purpose on a large lot of Hereford hides, for possible use as a sorting device that would aid in predicting leather strength and for better use of rawstock. For various reasons the accuracy of the results was not considered good enough for practical use, although Maeser (3) had found a similar approach at the wet-blue stage to be promising. Inaccuracy of the hide test was attributed to the fact that fiber orientation and fat deposits in the lower corium, which was later split off, were often distinctly different from the structure in the upper corium. The inability to obtain an accurate thickness measurement also contributed to the experimental error of this procedure.

In the course of that study (2) it was decided to apply the needle penetration test to the crust leather specimens before they were subjected to the standard ball burst test. Histological data from that study had confirmed a previous report (4) that fiber structure is directly related to leather strength. If the resistance to needle penetration actually reflects differences in fiber orientation, then application of the technique after splitting should give results that correlate with standard strength tests, and also offer the unique advantage of being essentially nondestructive.

Comparison of these leather tests showed very good correlation between penetrometer and ball burst values. Consequently, the new procedure was applied to a number of other Hereford leathers that were under investigation in connection with the vertical fiber defect. Heavy steer sides and lighter kip and calfskins were each tested. A common Hereford origin made the lot more suitable by avoiding the usual breed difference as an unknown source of variation. Inclusion of other standard physical tests and extension to 12 body locations afforded the opportunity for a thorough evaluation of the usefulness of the needle penetrometer for estimating leather strength.

EXPERIMENTAL

Sampling Scheme

As described previously (2), the duplicate crust leather specimens (two-inch disks) from the tannery trial were removed from the butt area adjacent to the site of needle penetrations in the cured hides. Penetrometer tests were performed near the edges of the specimen, followed by a ball burst test in the usual manner. For the other leathers evaluated, a standard 12-block pattern, fitted to the dimensions of each side, was inscribed in the form of three equal rows of four equal blocks per row. After cutting the test blocks, duplicate specimens for each test were removed from each block using a similar location for a given test. Two-inch disks were used for the penetrometer and the ball burst tests with an extra one for microscopic examination. Other specimens conformed to requirements of the test methods. Specimens for only three tests were removed from the calfskin leathers because of the small size of their test blocks. These tests were the penetrometer, the ball burst, and the tensile parallel.

Test Leathers

1. As described previously (2), a large tannery trial had been conducted on a group of cured, prefleshed Hereford hides consisting of 389 light-mediums (35 to 45 lbs.) and 56 heavies (55 to 80 lbs.). Based on the penetrometer value in the butt area of the cured hides, about 20 percent of the resultant sides were selected for further testing at the crust stage. The sides were being processed into four to five oz. shoe upper leather. The final test lot amounted to 90 sides, and included six with defective fiber structure, as shown in Table I (item 1).

TABLE I

SOURCES OF LEATHER SAMPLES EVALUATED

No.*	Leather Source	No. of Sides	No. of Locations	Total Samples
1.	Tannery Trial	90	1	90
2a.	Bullhides (normal)	13	12	156
2b.	Steerhides (normal)	21	12	252
2c.	Steerhides (defective)	9	12	108
3a.	Kipskins (normal)	10	12	120
3b.	Kipskins (defective)	2	12	24
4.	Calfskins (normal)	16	12	192

*Refers to descriptive paragraphs under Test Leathers, Experimental Section. Types of leathers involved are:

1—Crust shoe leather, 4–5 oz., including six defective sides.
2—Crust combat boot leather, 5½–6½ oz.
3—Crust or finished shoe leather, 3½–4½ oz.
4—Crust or finished slipper leather, 1½–2½ oz.

2. A comparison between leathers made from young Hereford bullhides (average cured wt. 60 lbs.) and comparable steerhides (average cured wt. 71 lbs.) from an inbred herd was discussed in a presentation by Bitcover (5). These sides were processed into a 5½ to 6½ oz. tropical combat boot leather and tested at the unbuffed crust stage. They are listed in Table I as Items 2a, 2b, and 2c and consisted of 13 bull sides and 21 steer sides with normal fiber structure, and nine steer hides showing the vertical fiber defect, respectively.

3. A set of 12 kipskin sides, processed as 3½ to 4½ oz. shoe upper leather, was provided by a tanner from several different production lots. Ten of these had been selected as "probably weak" on the basis of a "pulpy" appearance† on the flesh side, while the other two were representative of normal production. One of the selected group also showed an extremely corrugated pattern† right through

†Good pictures of this appearance were shown by Tancous (6).

the finish. This side and one other were found to have defective fiber structure, while the remaining ten did not, as shown in Table I (Items 3a, 3b). Since microscopic examination of all test specimens revealed red hair roots, all sides were presumed to originate from Herefords. Five of the ten normals were unfinished.

4. A set of 12 unfinished calfskins, processed as $1\frac{1}{2}$ to $2\frac{1}{2}$ oz. slipper leather, was provided by a tanner from known Hereford skins. They had been selected as suspect because of variable degrees of grain crack. Four finished, glazed calfskins obtained from another tanner, which seemed normal except for variable degrees of veininess, were added to these to make the lot of 16 shown at the bottom of Table I (Item 4). Red hair roots in the latter four suggested a Hereford origin and all 16 skins had normal fiber structure.

Experimental Penetrometer Test

The test instrument, designed and constructed in this Laboratory for use as a hide tester, is shown in Figure 1. Specification details were given in the previous publication (2). Essentially it consists of a steel needle 1/16 inch in diameter with a gradually tapering point, attached to the main shaft of a maximum-reading

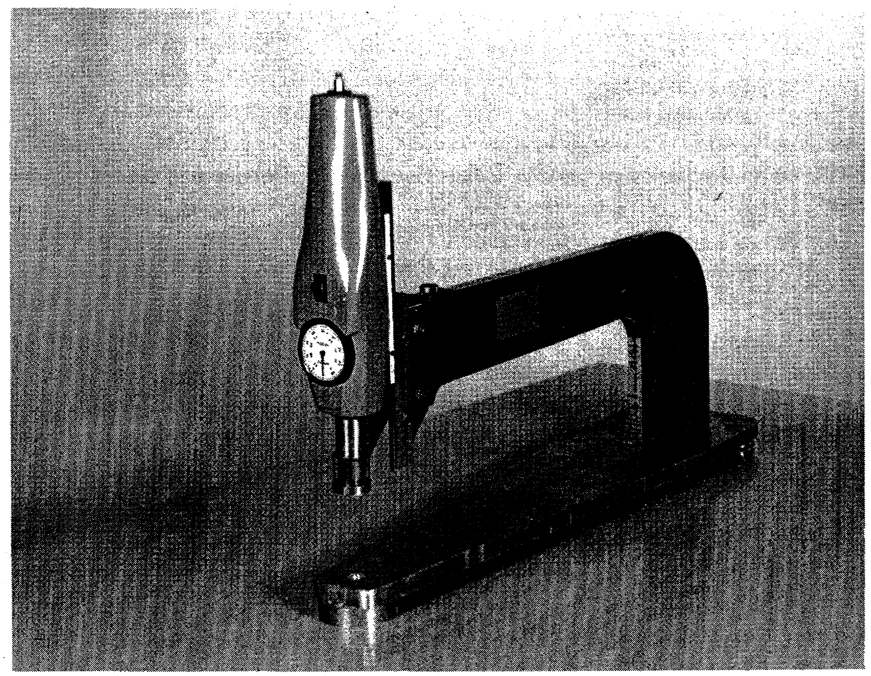

FIGURE 1.—Experimental penetrometer used for testing leather with grain side up. The force gauge in front records resistance, in lbs., to needle penetration, which is converted to thickness basis. Overall dimensions are about 21 x 5 x 8 in.

mechanical force gauge. This gauge assembly, with an attached, spring-loaded, presser foot mechanism, is connected to a supporting frame by means of vertically sliding tracks.

With a leather specimen in position, grain side up, on the base of the supporting frame, the gauge assembly is lowered to contact the specimen. By means of gradual, downward hand pressure on the gauge the needle is then forced through the specimen and into an open well beneath. At this point the gauge registers the maximum resistance in lbs., which constitutes the test load value. Specimen thickness, measured in the usual manner, is then used to calculate the final strength value in lbs./in. Three penetrations were made on each specimen and expressed as an average.

Theoretical considerations suggest that, if a needle with wedge-shaped and uniform taper were used, a modified thickness correction would give improved accuracy. The significance of this correction increases with the angle of taper. The sharpened portion of the needle used here, measuring 0.5 in. from tip to shank, is curved in cross section and unsuited to such calculations. Furthermore, the angle is so small ($<10^\circ$ average) that the simple thickness correction should be valid for practical purposes.

Standard Strength Tests

The standard ASTM ball burst procedure (7) using a ¼ in. ball was chosen as the original reference method, mainly because it is nondirectional, requiring only one pair of samples, and is a good general test for strength. The standard ASTM tensile test (7) and slit tear resistance (7) were also used, while stitch tear strength was determined by the double hole ALCA Method E 13 (8); these three tests were applied to separate specimens cut parallel and perpendicular to the backbone line. The SATRA** Lastometer (¼ in. ball) was used to perform the grain crack test, according to the IULCS method I.U.P. 9 (9), measuring the load and extension at grain crack but expressing the data on a thickness basis. Since the plan was to examine the correlations between the penetrometer and the standard tests on leathers with widely varying thicknesses, it was considered necessary to express all values from these tests on a thickness basis. All specimens were conditioned and tested at 23°C. and 50 percent relative humidity.

Statistical Methods

Correlations among the various tests were determined by calculating the linear correlation coefficients using the standard method (10). The 95 percent confidence limits (Figure 2) are considered to be prediction limits. They define the region within which 95 percent of all points, in further tests with similar samples, would be expected to fall.

**Reference to brand or firm name does not constitute endorsement by the U. S. Department of Agriculture over others of a similar nature not mentioned.

RESULTS

Correlation with Ball Burst in Tannery Trial

As described in the Introduction and Experimental sections, leather specimens from 90 experimental sides in the crust were first subjected to the penetrometer procedure and then to the standard ball burst to estimate the degree of correlation between these two methods. Results are shown in semigraphic form in Table II.

TABLE II

CORRELATION OF PENETROMETER AND BALL BURST ON CRUST LEATHER

Penetrometer† (lbs./in.)	Ball Burst Strength* (lbs./in.)					
	1200	1600	2000	2400	2800	3200
71–90	XX					
91–110		XXX	X			
111–130		X	XXXX XXXX XX	X		
131–150			XXXX	XXXX XXXX	XXXX	
151–170			XXXX	XXXX XXXX XXX	XXXX XX	
171–190				XXXX X	XXXX XXXX XXXX XX	XXXX XX
191–210					XXXX XX	XXXX

*Average of four measurements on two butt specimens. Numbers represent top of each bracket: 801–1200 1201–1600; etc.

†Average of six measurements on same two specimens. Broken lines represent cutoff points between weak and strong. Each "X" represents a test side from tannery trial, Table I. Correlation Coefficient (R) = 0.83.

Reasonable cutoff points indicated by distribution plots (2) are represented by the broken lines, and each "X" represents a side. The six weak sides selected by the ball burst cutoff appear to the left of the vertical line, while the six selected by the penetrometer appear above the horizontal line. In the upper left quadrant it can be seen that there was perfect agreement in five of the cases, all of which had defective fiber structure, while in adjacent quadrants there were two borderline cases of disagreement. Expressing the relationship in another way, the calculated correlation coefficient (R) for this set is 0.83, which is considered very good for two independent methods. This result encouraged us to conduct additional comparisons on other leathers.

Mixed-Lot Comparison

To expand the significance of this correlation, additional data were added from heavier Hereford bull and steer sides which had been processed into combat boot leather (see Experimental section). From the first four items shown in Table I, excluding eight of the normal steerhides, 125 sides were represented by a total of 510 samples in duplicate. Besides representing different types of leather, both with and without the vertical fiber defect, this mixed lot included samples from 12 anatomical locations to provide for a more critical comparison between the two methods. Correlation between the penetrometer and ball burst values, calculated by regression analysis, is plotted in Figure 2. The solid line best represents all of the points while the broken lines show the 95 percent confidence limits (see Experimental section for definition). A correlation coefficient of 0.77 was calculated from these somewhat dissimilar samples. This is further assurance of the good correlation between the two methods.

Influence of Hide Maturity

During an attempt to extend the correlation study by plotting composite data from Hereford steer, kip, and calfskin leathers, excessive scattering of the points

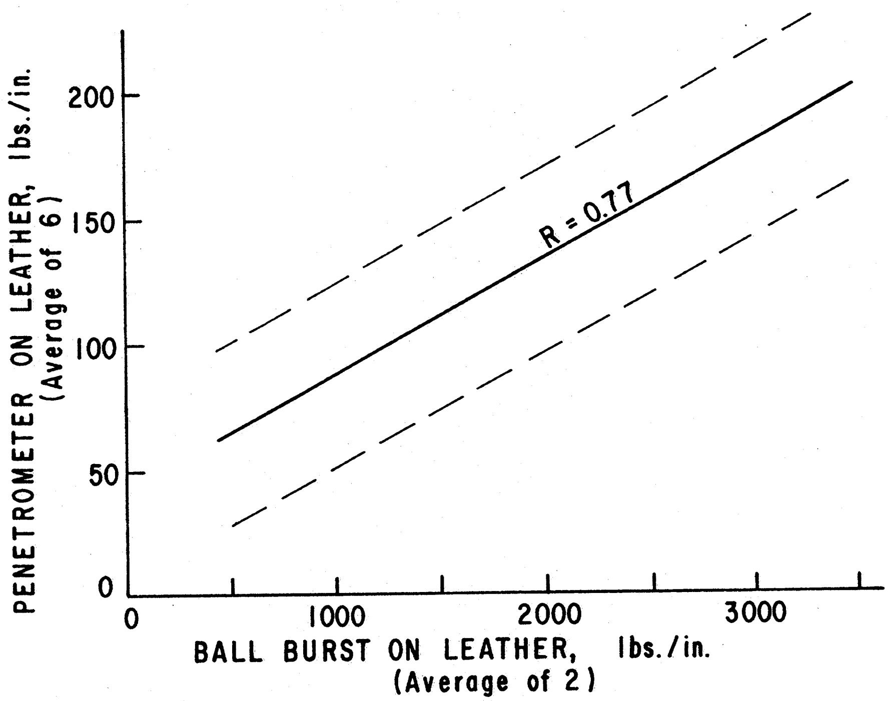

FIGURE 2.—Correlation between penetrometer readings and ball burst strength for 510 specimens in duplicate, from a mixed lot described in Table I (Items 1 and 2). The correlation coefficient (R) indicates good agreement between the tests. Broken lines show the 95 percent confidence limits.

suggested that the three maturity types should be analyzed separately. The numbers and types of sides and samples involved in these considerations are shown in Table I (Items 2b and 2c, 3a and 3b, and 4). There were 360 samples in duplicate from steerhide, 144 from kipskin, and 192 from calfskin leathers. The separate regressions for these three groups are plotted as solid lines in Figure 3,

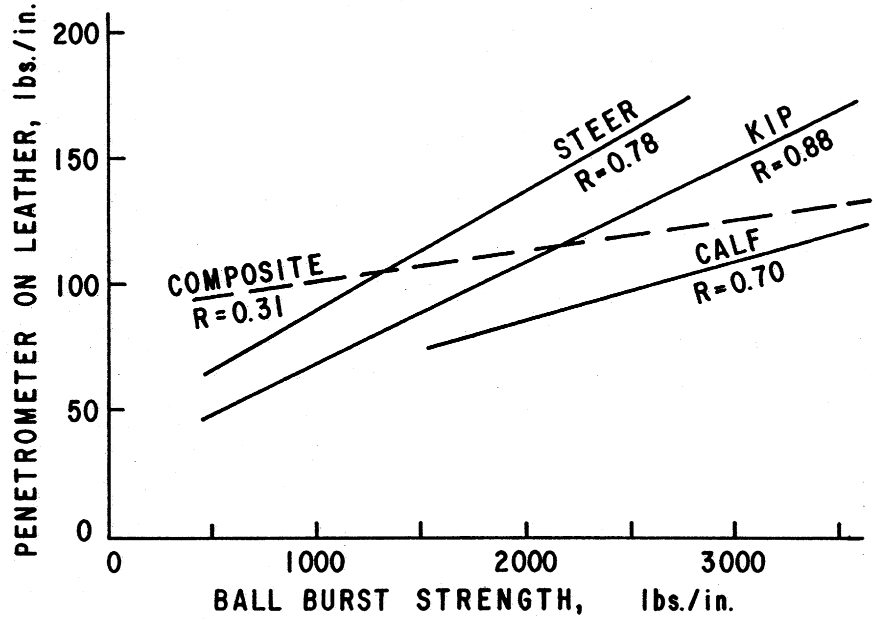

FIGURE 3.—Correlations between penetrometer readings and ball burst strength for three maturity types of leather compared with the composite mixture, showing the importance of separate evaluation of correlation coefficients (R). Source material is described in Table I (Items 2b and 2c, 3a and 3b, and 4).

while that for the composite mixture is shown by a broken line. It is evident that they constitute different categories. Further statistical analyses, comparing steer *vs.* kip and kip *vs.* calf, confirmed that the differences in slope are highly significant. Note especially that the correlation coefficients (R) for the separated groups are 0.7 or better in all cases, again assuring the close relationship between the two methods, whereas the coefficient for the composite is only 0.3. The nature of the stock in terms of its relative maturity thus appears to be a limiting factor in comparative studies of such leather properties.

To examine further the variation in leather strength with hide maturity, and to indicate the separate influence of finishing, data from the sides with normal structure listed in Table I (Items 2b, 3a, and 4) were calculated as side averages for each of the 13 physical tests applied and were further subdivided into appropriate groups. These results are shown in Table III. The first nine tests measure

TABLE III

INFLUENCE OF HIDE MATURITY AND FINISHING ON LEATHER PROPERTIES

Physical Test*	Units	Calf†		Kip‡		Steer**
		Finished	Unfinished	Finished	Unfinished	Unfinished
Ball Burst	lbs./in.	2918	2626	2142	1953	1831
Penetrometer	lbs./in.	101	102	113	105	129
Tensile, parallel	(p.s.i.)	4734	4594	3612	3039	2594
Tensile, perpendicular	(p.s.i.)	—	—	2872	2459	2084
Slit Tear, parallel	lbs./in.	—	—	572	498	525
Slit Tear, perpendicular	lbs./in.	—	—	615	535	559
Stitch Tear, parallel	lbs./in.	—	—	1037	876	—
Stitch Tear, perpendicular	lbs./in.	—	—	1067	906	—
Grain Crack Load	kg./cm.	—	—	142	148	172
Grain Crack Ext.	mm./cm.	—	—	42	43	36
Ball Burst Ext.	in./in.	11.3	9.96	5.68	5.83	4.71
Tensile Ext., parallel	in./in.	60.8	54.0	27.4	28.7	18.4
Tensile Ext., perpendicular	in./in.	—	—	39.7	36.6	24.3
Tensile Elong., parallel	(%)	39	38	43	50	42
Tensile Elong., perpendicular	(%)	—	—	63	64	54

*Values are side averages from duplicate determinations on samples from normal sides in Table I, Items 2b, 3a, and 4. The first 9 tests are considered to measure strength while the others measure stretch.

†Based on four finished and 12 unfinished normal sides.

‡Based on five finished and five unfinished normal sides.

**Based on 21 unfinished normal sides.

strength while the last four measure stretch. Tensile "elongation" expressed as percent is also included for comparison with the linear "extension" on a thickness basis. Values from almost all of the tests showed an appreciable decrease with increasing maturity, although the penetrometer, slit tear, and grain crack load tests indicated a slight increase in strength. Stitch tear measurements were made only on the kip sides because this test was one of the specification requirements for this particular type of leather. Since the slit tear was considered a preferable test but was possibly operating by a different mechanism (11), results from these two tests were correlated with each other. The correlation coefficient for the parallel specimens was 0.738, and for the perpendicular specimens it was 0.769, confirming the close relationship between results by the two methods.

Influence of Finishing

The set of ten normal kip sides in Table III is the most suitable for evaluating the effect of finishing since the set consisted of five finished and five unfinished sides. Here it is evident that, except for the grain crack load test, finished sides exhibited consistently higher strength values but very little difference in stretch properties. Although the data suggest definite trends in regard to finishing, the significance of the conclusion is limited because relatively small numbers of unmatched sides were involved. Nevertheless, the possible influence of impregnating and finishing materials should not be overlooked in evaluating test methods.

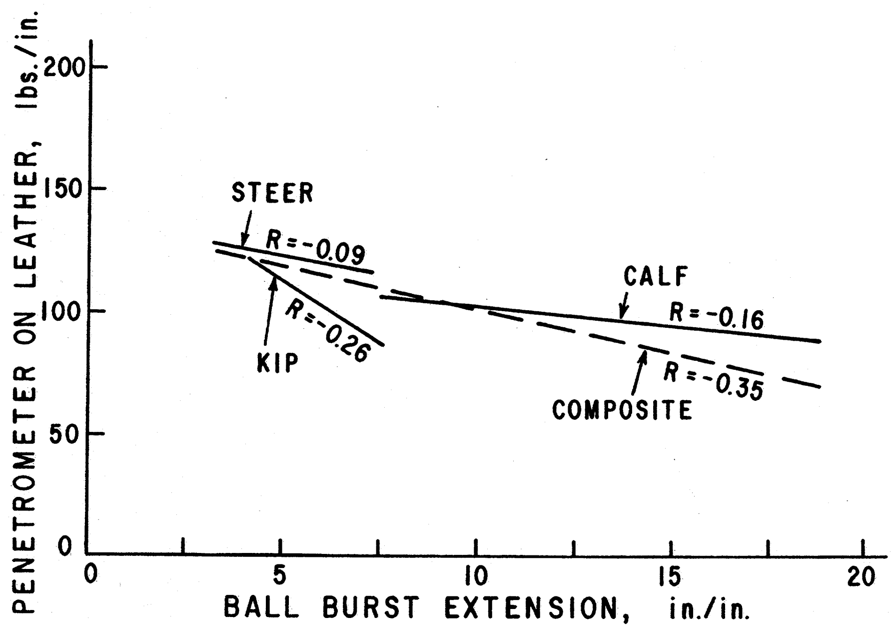

FIGURE 4.—Correlations between penetrometer readings and ball burst extension for the same material shown in Figure 3. Negative correlation indicates the distinct difference between the penetrometer and stretch tests.

Correlation with Other Standard Tests

Using data from the same material as was used in Figure 3, shown in Table I as Items 2b and 2c, 3a and 3b, and 4, penetrometer values were also correlated with each of the other standard tests applied. In each case the two or three maturity types were evaluated separately and as a composite, as was shown in Figure 3. Regressions were plotted for each comparison but the calculated correlation coefficients seem to be the simplest expressions of such correlations, and these values are tabulated in Table IV for all 12 comparisons, the last six involving stretch properties. Here it can be seen again that the separate coefficients for each maturity type are usually much larger than that for the composite, confirming the need for separation into maturity groups. Also the correlations with the tensile, slit tear, and grain crack load values are almost as good as the correlation with the ball burst. The grain crack extension and other stretch tests are poorly correlated with the penetrometer, all coefficients being very small or negative, showing that these tests measure a distinctly different property. For comparison with Figure 3, which shows the positive correlations of penetrometer values with ball burst strength, Figure 4 shows the negative correlations with ball burst extension.

TABLE IV

CORRELATIONS BETWEEN PENETROMETER AND STANDARD TESTS
INFLUENCE OF SEPARATION INTO MATURITY GROUPS

Test* Comparisons		Correlation Coefficients (R)			
X-Axis	Y-Axis	Steer	Kip	Calf	Composite
Ball Burst	Penetrometer	0.775	0.884	0.701	0.310
Tensile, parallel	"	0.440	0.743	0.468	0.108
Tensile, perpendicular	"	0.440	0.686	—	0.381
Slit Tear, parallel	"	0.523	0.740	—	0.556
Slit Tear, perpendicular	"	0.448	0.735	—	0.501
Grain Crack Load	"	0.320	0.689	—	0.461
Grain Crack Ext.	"	0.165	0.391	—	0.102
Ball Burst Ext.	"	—0.087	—0.258	—0.164	—0.354
Tensile Ext., parallel	"	—0.148	—0.245	—0.253	—0.377
Tensile Ext., perpendicular	"	—0.077	0.136	—	—0.156
Tensile Elongation, parallel (%)	"	—0.219	—0.272	—0.250	—0.160
Tensile Elongation, perpendicular (%)	"	—0.180	0.185	—	—0.104

*All except last test are expressed on thickness basis for comparability among maturity groups, as in Table III. Upper half of table includes strength tests, lower half stretch tests. Data from samples in Table I as follows: steer — Items 2b and 2c; kip — Items 3a and 3b; calf — Item 4.

This relationship is typical of those found for the other stretch properties as well, although there were differences in degree, as indicated by the coefficients in Table IV. For some reason the kip data gave the best correlations in almost every case.

DISCUSSION

Reid and Maeser (12) have reported on the correlations among a number of leather tests, indicating that the same general trends are shown by all tests within a group but pointing out the importance of attention to stretch or distortion properties as well as to the conventional measurements of strength. Kanagy (13) has reviewed this whole area of concern in some detail. It seems apparent that the penetrometer, in view of the correlations shown, might well qualify as a new strength test. Unlike the ball burst or Lastometer tests, however, it does not yield information directly correlated with stretch properties, so that its relation to lastability might be questioned. Maeser's (3) correlation of a penetration test on blue stock with a calculated "lastability factor" suggests a fairly close relationship to lasting performance, which is encouraging.

The results from the kip sides were of interest in connection with attempts to detect vertical fiber or "pulpiness" on the flesh side by visual sorting in the crust. Of the ten sides that were selected as pulpy, only two were actually defective. One of these had an obvious, severely corrugated appearance whereas the other one did not. A third side had borderline strength but four of those selected as pulpy were stronger than the two picked as normal. It became evident that the visual appearance was not a reliable index of fiber structure or strength in these sides.

It is recognized that the extensions recorded in the tensile, ball burst, and grain crack tests are normally expressed in linear units and are not corrected for thickness. In comparing heavy steer leather with kip and calf, however, it was considered advisable to correct all the measurements for thickness. Justification for this change seems less apparent in the case of the tensile test, where the stretching force is applied in a strictly lateral direction. For this reason the normal "percent elongation" values were also included in Tables III and IV. Only slight differences can be seen in their trends and correlations.

The needle penetrometer is thought to be better suited to quality control applications because of its relative simpliciy and nondestructiveness. The term "nondestructive" is used in its practical sense, meaning that the pinholes produced cause no gross damage, destruction, or removal of material that would reduce the value of the leather or noticeably impair its properties. Application to wet blue stock would most probably leave no recognizable marks on the finished leather. It is envisioned that the penetrometer test might be used to sort leather production into three broad classes: abnormally weak, normally strong, and exceptionally strong. This would provide better guidelines for appropriate end uses and fabrication procedures. For example, separate tension settings might be determined for lasting machines so that failures from too much or too little pullover could be minimized.

CONCLUSIONS

1. When applied to crust or finished leather, the needle penetrometer shows an acceptable degree of correlation with standard strength tests such as the ball burst, tensile, and slit tear, and might therefore serve as a useful new method of this type. It has the unique advantage of being essentially nondestructive.

2. Since correlation is very poor with tests such as grain crack extension, ball burst extension, and tensile elongation, the method is not a useful measure of stretch properties.

3. Comparisons of physical properties among steer, kip, and calf leathers indicate the need for evaluating these maturity classes separately.

4. On the basis of limited tests, finishing tends to increase strength values but shows little effect on stretch.

ACKNOWLEDGMENTS

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REFERENCES

1. Amos, G. L. *J. Soc. Leather Trades' Chemists,* 42, 79 (1958).
2. Everett, A. L., Palm, W. E., Bitcover, E. H., Scherr, H. J., Hannigan, M. V., and Naghski, J. *JALCA,* 68, 84 (1973).
3. Maeser, M. *JALCA,* 67, 302 (1972).
4. Everett, A. L., Hannigan, M. V., Bitcover, E. H., Windus, W., and Naghski, J. *JALCA,* 66, 161 (1971).
5. Bitcover, E. H., Everett, A. L., Palm, W. E., Windus, W., and Naghski, J. *Leather Mfr.,* 88, (7), 21 (1971).
6. Tancous, J. J. *JALCA,* 61, 4 (1966).
7. American Society of Testing Materials, Book of ASTM Standards, Part 15: methods D2207-64, D2209-64, D2212-64 (1972).
8. Official Methods of Analysis, ALCA (1957). May be secured from the Secretary-Treasurer of ALCA, Tanners' Council Research Laboratory, University of Cincinnati, Cincinnati, Ohio 45221.
9. *J. Soc. Leather Trades' Chemists,* 44, 371 (1960); official method, *ibid.,* 45, 375 (1961).
10. Steel, R. G. D., and Torrie, J. H. "Principles and Procedures of Statistics," McGraw-Hill Book Company, Inc., New York, 1960.
11. Carter, T. J. *JALCA,* 60, 4 (1965).

12. Reid, J. A., and Maeser, M. *JALCA,* 62, 468 (1967).
13. Kanagy, J. R. in "Chemistry and Technology of Leather," O'Flaherty, F., Roddy, W. T., and Lollar, R. M., Editors, Vol. 4, p. 369, Reinhold Publishing Corp., New York, 1965.

DISCUSSION*

MRS. JEAN TANCOUS (Tanners' Council Research Laboratory): I am sure I speak for the tanning industry when I express thanks to the United States Department of Agriculture for its concern about a serious problem inherent in hides of Hereford cattle. The incidence and predictability studies done in the Tanners' Laboratory six years ago were sponsored by the Department. Al Everett published an interesting paper on the histology of pulpy hides and pulpy leather in 1966 and presented a paper two years ago concerned with the influence of heredity on pulpiness. Today we also heard Dr. Bitcover's findings on bull hides. Al gives the tanner a relatively nondestructive test for establishing whether or not a side of leather is pulpy. The test is more reliable than using characteristics of feel and appearance to identify the condition. Al also has been making a study of the effects of feeding on pulpiness. We look forward to hearing the results of these studies in a future paper. We certainly thank Al and his co-workers for their important papers. As a question now, I would like to know what the cost of the penetrometer would be and whether or not it could be placed conveniently on or near the inspector's table.

MR. EVERETT: I'm afraid it's a little too early yet, Jean, to answer that directly. The only instrument we have made so far is a test device for research purposes, but it does seem in principle to be simple enough that the cost of making a suitable device and using it would be quite practical and take very little time as well. Sorry I can't give any definite idea of the cost for industrial use.

MRS. TANCOUS: Would one puncture be enough or would two or three be necessary for testing?

MR. EVERETT: I believe at least three would be needed. We used five routinely, just to be on the safe side. On analyzing the data, we find that the first three are really all we need. I wouldn't want to trust any less than three, however.

MRS. TANCOUS: Are there any questions from the floor?

MR. MALCOLM H. BATTLES (A. C. Lawrence Co.): Al, have you done any further work on using the penetrometer on blue stock after splitting and is that similar to what Slim Maeser was doing?

MR. EVERETT: No, we haven't, Mal. We feel that either testing the cured

*This discussion also applies to the paper entitled "Evaluation of a Needle Penetrometer for Detecting Weak Hides Before Processing" by A. L. Everett, W. E. Palm, E. H. Bitcover, H. J. Scherr, M. V. Hannigan, and J. Naghski (*JALCA,* 68, 84–95 (1973)).

hide before processing or just later as a final leather test are all we should attempt to do so far. Perhaps the moisture content and things of that sort may play a part in how the needle performs and might be a little too variable to risk using wet stock.

MR. BATTLES: I don't think you should overlook it, though.

MR. EVERETT: It is a good spot for the tanner to take a look, I realize that.

MR. BATTLES: Ideally, it would be nice to sort these hides out before they go into process at all, but if this does not turn out to be possible there is still the opportunity for the tanner to select these in the blue and put the weaker hides into leathers that are not as sensitive to weakness.

MR. EVERETT: It is a good thought.

MR. BATTLES: Also, you mentioned the need for three needle punctures as a minimum. Do you remember the device that Maeser built that would automatically average five measurements? Possibly you could do something similar on this one.

MR. EVERETT: Yes, I think you are right. Simultaneous punctures, at least three, perhaps even five in a relatively small area, would be highly desirable.

MRS. TANCOUS: Any other questions? If there are no more questions, I thank Al again for an important contribution to quality control.