

Studies on the determination of thickness, mass per unit area and the apparent density of leather

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A method to verify and determine precision data from the procedures for determining thickness (ISO 2589), apparent density and mass per unit area of leather (ISO 2420) was used in an inter-laboratory test of leather samples.

This study was on behalf of a Leather Testing and Assessment commission set up by VGCT, the German Association of Tanning Chemists and Technicians.

Introduction

The thickness of leather is an important parameter for the characterisation of the material itself and for calculating further physical-mechanical parameters. This determination is described in ISO 2589^[1], where the sample is placed in a defined test machine, loaded with a specified load for a specified time, and then the thickness value read directly.

Apparent density and mass per unit area are material characteristics that play a role in the course of weight reduction. This is an important factor in weight reduction for the construction of vehicles and for clothing, where a lower apparent density is an important component for an increase in wearer comfort.

The determination of these parameters is based on the measurements of mass, thickness and the dimensions of the specimens. This involves calculating the ratio of mass to volume for the apparent density, and of the mass to area for the mass per unit area^[2,3].

These determinations do not present any difficulty when using a suitable balance. However, the accuracy of the apparent density and mass per unit area determinations is particularly dependent on the accuracy of measurement of the dimensions (thickness, diameter or side lengths) of the specimen.

The aim of the inter-laboratory test, initiated by the VGCT's Leather Testing and Assessment commission, was therefore to verify the method of these two standard testing procedures.

The approach to the investigation

Twelve laboratories from the leather industry, the chemical industry and the testing service sector participated in the inter-laboratory investigation.

Because leather is a heterogeneous material, additional factors had to be taken into account in designing a round-robin test. Here, the concept for an inter-laboratory test as proposed in ISO 5725-5^[4] implies a high material and testing effort and consequent considerable cost.

Ways were sought to simplify the test to provide a maximum amount of information from a justifiable input.

Details of the investigation

Three leather samples and one leather fibre board were tested in this study:

Sample P1 – smooth bovine leather, black, round specimens

Sample P2 – embossed bovine leather, beige, round specimens

Sample P3 – goat leather, grey, square specimens

Sample P4 – leather fibre board, square specimens

The sampling and sample preparation were performed centrally. After conditioning (23°C, 50% relative humidity), all the relevant parameters (mass, thickness, diameter or side length) were measured by the organising laboratory. These reference measurements were intended to eliminate any heterogeneity effects in the sample.

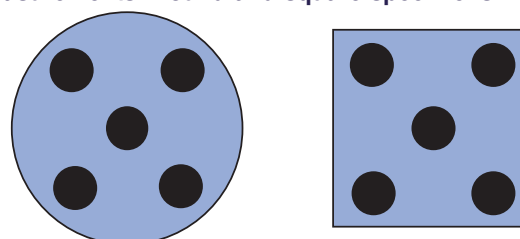
Once measured and numbered, the specimens were wrapped in aluminium foil, and shipped at the same time to the participants. Each laboratory received one round specimen (P1 and P2) and two square specimens (P3 and P4). Prior to measurement in these laboratories, the specimens were stored again for at least 48 hours in defined conditions^[5] (23°C, 50% relative humidity).

The concept of these tests included repeated measurements of the same specimen, each measurement occurring at different days in a limited period (within 7 days). For samples P1 and P2, three determinations were performed, whereas two determinations were made for samples P3 and P4. The measurements of mass, diameter or side length and thickness always took place exactly according to the corresponding standard^[1,2,3]. For thickness measurements, position points were defined for both specimen variants as shown in *Panel 1*.

Findings from the investigation

Due to the nature of the materials and the test format used, statistical analysis of the data sets as determined to the standard ISO 5725-2^[6] resulted in values that were partially inconsistent. Here, alternative evaluation methods were used to eliminate the heterogeneity content from variations within these values (ISO 5725-5^[4]).

Panel 1: Measuring point positions for thickness measurements: Round and square specimens.





However, these methods require a certain amount of the data set that was not given for all of the samples that were tested. The precision parameters for samples P3 (leather) and P4 (leather fibre board) are summarised in *Panel 2*.

Due to the structure and production process, the leather fibre board^[7] shows a higher homogeneity and compactness than leather. The data reflects this and shows that:

- The portion of heterogeneity V_H is lower for the leather fibre board sample P4.
- At comparable thickness, the values for apparent density and mass per unit area are higher than for the leather sample P3.
- The precision under both repeatability and reproducibility conditions for both assessed samples (P3 and P4) are good.

The measurements of average thickness on three days for samples P1 and P2 are shown in *Panels 3 and 4*.

Within these findings, the low thickness value of sample P1, shown in *Panel 3*, as determined by Lab 14 was confirmed to be correct by measurements done by the reference lab (Lab 11) and has to be ascribed to the heterogeneity of the material. Similarly, in the case of sample P2, the specimens showed even more pronounced thickness variations.

Due to the format of these inter-laboratory tests, fewer results were obtained from samples P1 and P2. No precision data could be calculated for the data sets of these samples, only averages of thickness, apparent density and mass per unit area. The corresponding variations are given in *Panel 5*.

Conclusions

Within the field of inter-laboratory investigations associated with the physical testing of leather, a differentiation between variations of the measuring procedure and the properties of the sample (from within the hide and from hide to hide) can only be achieved by an appropriate design and distribution of the sample material.

Moreover, considering the nature of the material and the testing effort involved, costs have a restrictive impact on the design and concept of an inter-laboratory test. A compromise is always required between obtaining the maximum amount of information and the costs that are incurred.

However, these inter-laboratory tests verified the methods used. Precision data was provided for the procedures of thickness, apparent density and mass per unit area for both leather and leather-fibre board.

At the same time, variations of these properties were identified due to the procedure and the material. The investigation shows that the performance characteristics (repeatability and reproducibility) of the procedures used can provide accurate data, except in cases when it is caused by any lack of homogeneity within the material sample.

Acknowledgement

VGCT thanks all participants of the inter-laboratory test for their cooperation and discussions as well as the provision of sample material.

Literature

- [1] ISO 2589 – Leather – Physical and mechanical tests – Determination of thickness, 2003
- [2] ISO 2420 – Leather – Physical and mechanical tests – Determination of apparent density, 2003
- [3] DIN 53327 – Prüfung von Leder – Bestimmung der Rohdichte und der flächenbezogenen Masse, 1989

Panel 2: Precision parameters of the standardised procedures for the determination of thickness, apparent density and mass per unit area.

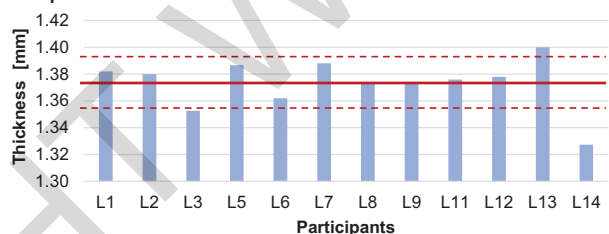
(Parameters calculated with an algorithm appropriate for heterogeneous materials).

Parameter	Thickness		Apparent density		Mass per unit area	
	Leather P3	Leather fibre board P4	Leather P3	Leather fibre board P4	Leather P3	Leather fibre board P4
Repeatability variation coefficient V_r , [%]	1.1	0.7	0.9	0.6	0.2	0.3
Repeatability limit r , P=95 %, [%]	3.1	1.9	2.4	1.7	0.7	0.9
Reproducibility variation coefficient V_R , [%]	2.1	1.0	1.2	0.7	0.9	1.5
Reproducibility limit R , P=95 %, [%]	5.9	2.9	3.4	2.0	2.6	4.3
Heterogeneity proportion V_H , [%]	5.9	1.3	3.0	1.2	4.5	2.6
Thickness average [mm]	0.795	0.803				
Apparent density average [g/cm ³]			0.679	0.857		
Mass per unit area average [g/m ²]					537	687
Eliminated outliers, Lab-No.	-	-	-	5.14	9.13	9.14

P – Probability

Panel 3: Averages of thickness measurements for the same specimen on three different days.

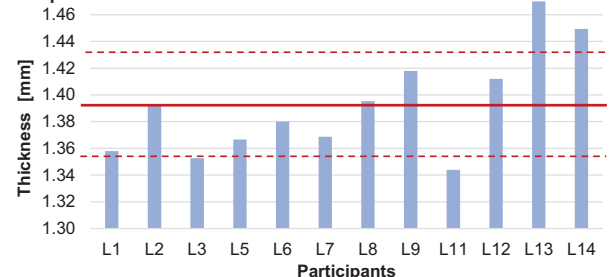
Sample P1



The red continuous line corresponds to the overall average of all specimens of leather P1; the dashed lines correspond to the simple standard deviation ($\pm s$)

Panel 4: Averages of thickness measurements for the same specimen on three different days.

Sample P2



The red continuous line corresponds to the overall average of all specimens of leather P2; the dashed lines correspond to the simple standard deviation ($\pm s$)

Panel 5: Measurements of thickness, apparent density and mass per unit area of leather samples: Samples P1 and P2 averaged over three days with the corresponding variations.

Parameter	Thickness		Apparent density		Mass per unit area	
	Leather P1	Leather P2	Leather P1	Leather P2	Leather P1	Leather P2
Thickness average [mm]	1.37	1.39				
Apparent density average [g/cm ³]			0.671	0.710		
Mass per unit area average [g/m ²]					921	991
Variation min [%]	-3.3	-3.5	-2.8	-2.0	-4.5	-4.5
Variation max [%]	1.9	5.6	2.3	4.0	2.9	5.3

- [4] ISO 5725-5 – Accuracy (trueness and precision) of measurements and results. Part 5: Alternative methods for the determination of the precision of a standard measurement method, 2002
- [5] EN ISO 2419 – Leather – Physical and mechanical tests – Sample preparation and conditioning, 2012
- [6] DIN ISO 5725-2 – Accuracy (trueness and precision) of measurements and results. Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method, 2002
- [7] EN 15987 – Leather – Terminology – Key definitions for the leather trade, 2015