Measurement of Two-Dimensional Extension

1   Scope

This method can be used with any type of light leather.

2   Principle of the method

The specimen, which consists of a circular disk, is clamped at its edges and pressure is applied hydrostatically to its flesh surface. This causes the disk to distend and assume a form which is approximately that of a spherical cap. The changes which occur in the grain surface and finish are observed and the heights of the cap are noted at various pressures; from these heights the area extension of the specimen is calculated.

3   Preparation of specimens

It is informative to make tests on specimens conditioned at a low and a high relative humidity as well as at the standard relative humidity of 65%. Cut as circular disks of 68 mm diameter, two specimens for use at 65% relative humidity and one specimen for conditioning at each of the other humidities which are specified (see 7.2). One of the two specimens for the standard humidity is used merely for adjustment of the apparatus (see 5.1) and not for measurement. Condition both these specimens in accordance with the method given in SLP 3 and measure the thickness of that which is to be used for measurement in accordance with the method given in SLP 4. If tests at other humidities are specified, condition one specimen at each humidity (see 7.2) and measure its thickness in the same way.

4   Description of apparatus*

The apparatus consists of the following parts:

4.1   A metal head in which the specimen is clamped for testing with an oil resistant rubber diaphragm beneath it. The dimensions and functions of the various parts of the head are indicated in the sectional elevation shown in Fig 1.

4.2   A constant output rotary oil pump and valves which can be set to raise the pressure applied to the leather to 10 kgf/cm² in 30 seconds (see the schematic diagram in Fig 2).

4.3   To indicate the pressure, a manometer reading from 0 to 25 kgf/cm² and having errors not greater than 0.1 kgf/cm² at any part of its range.

4.4   Means for recording automatically in graphical form the pressure applied to the leather and the corresponding height of the spherical cap, the pressures being plotted as ordinates and the heights as abscissae (a suitable arrangement is indicated in Fig 2). The pressures recorded automatically must have errors not greater than 0.1 kgf/cm² and the heights of the cap must not have errors greater than 0.5 mm.
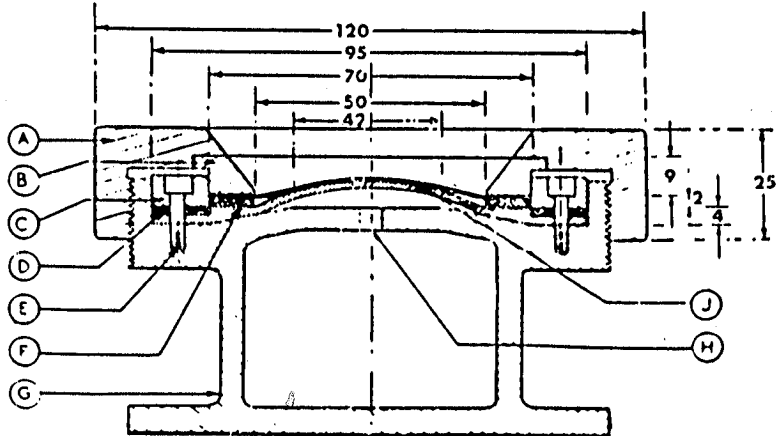
A. Screwed clamping ring 120 mm o.d. x 25 mm thick.
B. Upper grip ring.
C. Diaphragm clamping ring 95 mm o.d. x 70 mm i.d.
D. Rubber diaphragm (with inset metal ring 95 mm o.d. x 70 mm i.d. x 2 mm thick).
   Diaphragm 2 mm thick over operative area. The rubber diaphragm must be such that
   when it is clamped without any leather a pressure of 0·1 kgf cm² raises its midpoint
   by at least 20 mm. Diaphragm shown in partially distended position.
E. Socket head screws for securing (C).
F. Lower grip ring.
G. Hydraulic cylinder casting.
H. Oil way, feeding oil pressure to underside of (D).
J. Leather diaphragm under test (all dimensions , 0·02 mm).

Fig 1   Sectional elevation of apparatus (dimensions in millimetres)
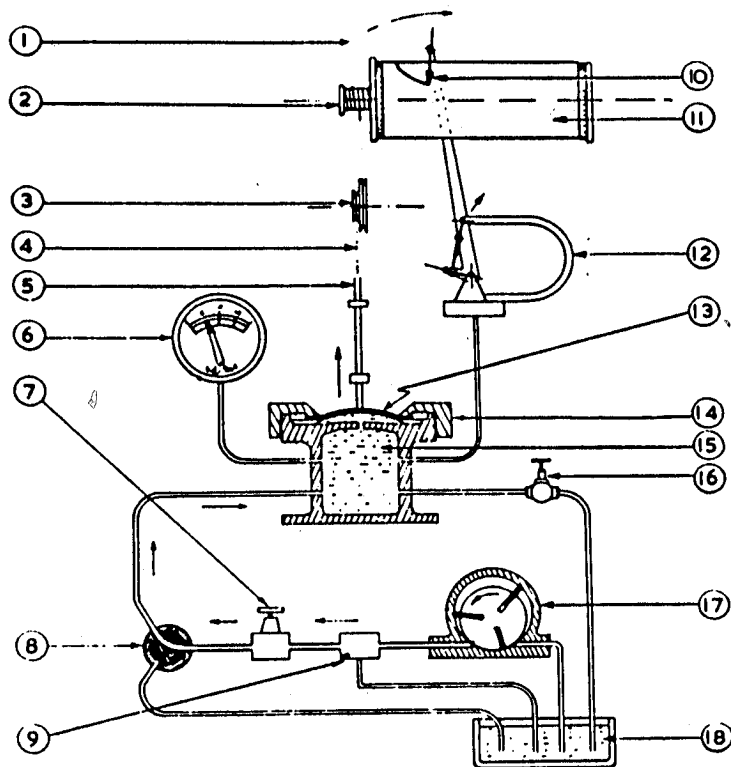
1. Cord to jockey pulley and counterpoise (not shown).
2. Helical vee grooved pulley, integral with 11.
3. Compound jockey vee pulley on miniature ball bearings.
4. Cord attached to 5.
5. Vertical rod, counterpoised by 1, sliding in antifriction bearings. The diameter of the rod is 6·25 mm, and it applies to the leather a load not greater than 25 g.
6. Pressure gauge, 0·25 kgf/cm².
7. Adjustable rate of flow valve.
8. Three-way valve.
9. Relief valve.
10. Pen.
11. Recording drum on miniature ball bearings.
12. Bourdon tube operating recording pen.
13. Leather test sample.
14. Clamp ring.
15. Test vessel.
16. Outlet valve.
17. Constant output rotary oil pump.
18. Oil sump.

Fig 2   Schematic diagram of apparatus and key

5   Procedure

5.1   Securely clamp in the head the specimen which is merely to be used for adjusting the apparatus. Set the valves of the pumping system so as to cause the pressure to rise from zero to 10 kgf/cm² in (as nearly as possible) 30 seconds. Release the pressure and remove the specimen (see 7.4).

7　Notes

7.1　The method can be used with suede leathers whose flesh surface has been buffed, but for these leathers the sueded flesh surface must be regarded as the 'grain'.

7.2　A suitable method of conditioning specimens at low humidity is to suspend them for 48 hours in an enclosed space at 20 ± 1 °C over a saturated solution of magnesium chloride (relative humidity 34%), with some arrangement for keeping the air in the closed space in movement. A suitable method for conditioning specimens at a high humidity is to suspend them similarly but over water instead of over magnesium chloride solution.　Specimens so conditioned must be removed one at a time for test in the standard atmosphere at 65% relative humidity, and tested immediately to minimise reconditioning in that atmosphere.

7.3　To assess why some leathers give good results at one humidity and not at another, it may be desirable to weigh specimens to find how their moisture content changes during conditioning, but such measurements should be made on extra specimens and not those used for the distension tests.

7.4　If several specimens of the same leather or several specimens of similar leathers are to be tested, it is not necessary to adjust the apparatus repeatedly as described in 5.1; it is sufficient to make the adjustment once, when the testing of the group of specimens is begun.

7.5　Poor adhesion of the finish at maximum extension may be shown by rubbing the cap lightly with a white cotton fabric as the extension approaches the maximum or by pressing an adhesive tape against the cap and peeling it off again.

7.6　To calculate the percentage area extension, A, the leather is clamped in the apparatus, leaving a circular disk of 50 mm diameter free to distend under pressure.　The area of the distended leather is to be taken as that of the spherical cap to which it corresponds approximately in form; *viz*, a cap of the same height, h mm and bounded by a plane which it intersects in a circle of 50 mm diameter.　The percentage extension of the area of the leather is therefore A, where $A = 0.16h^2$.

7.7　To calculate the percentage radial extension, R, take the linear extension as being the same along all radii, and at all distances from the centre.　Then the percentage radial extension, R, is given by the equation:

$$R = 100 \left[\frac{\alpha}{\sin\alpha} - 1 \right]$$

where $\alpha = \cos^{-1}[1 - (h/r)]$, and the radius of curvature r of the cap is given in millimetres by the equation, $r = (h^2 + 625)/2h$.　The values of R corresponding to various values of h are shown in Table 1.

5.2   Securely clamp another specimen in the head, with the grain upwards and exposed to view.

5.3   Switch on the pump and observe the leather for the first signs of cracks in the finish and for first signs of cracks in the grain of the leather itself. If either occurs, record the relevant pressure on the pressure-height curve by a momentary interruption in the increase of pressure with the aid of valve 8 (Fig 2), or by other suitable means.

5.4   Unless a pressure other than 15 kgf/cm^2 is specified or the specimen bursts at a pressure below 15 kgf/cm^2, allow the pressure to rise to 15 kgf/cm^2.

5.5   As soon as the pressure reaches 15 kgf/cm^2 (or other specified maximum pressure), allow the pressure to fall again at approximately the same rate as it was increased. While the pressure is at or near its maximum, note whether there is good adhesion of the leather finish to the grain of the specimen.

5.6   From the graph of pressure versus height of cap, h, measure h in millimetres at pressures of 5 kgf/cm^2, 10 kgf/cm^2 and 15 kgf/cm^2 on the ascending pressure branch, and at 10 kgf/cm^2 and 5 kgf/cm^2 on the descending branch.

5.7   Examine the specimen when it is removed from the head. If there is any sign that slip has occurred, the results must be rejected and the test repeated, with extra precautions against slip if necessary (see 7.9).

5.8   If specimens have been conditioned at other humidities, test them with the minimum of delay in accordance with 5.2 to 5.7 (see 7.2).

6   Statement of results

For each specimen, report such of the following quantities as the maximum pressure allows to be measured:

(1)   Thickness of the specimen before its use on the apparatus.

(2)   The percentage area extension and the percentage radial extension at first crack of the finish, at first crack of the grain, and at burst of the leather (see 7.6 and 7.7).

(3)   The percentage area extension and the percentage radial extension at 5 kgf/cm^2, 10 kgf/cm^2 and 15 kgf/cm^2 with pressure increasing, and at 10 kgf/cm^2 and 5 kgf/cm^2 with pressure decreasing.

(4)   The pressure and the linear tension at first crack of the finish, at first crack of the grain and at burst of the leather (see 7.8).

(5)   The adhesion of the finish at maximum pressure (see 7.5).

Table 1 Values of the percentage radial extension R for various values of the cap height h, where h is in millimetres.

h	R	h	R	h	R	h	R	h	R
0.25	0.01	5.25	2.9	10.25	10.9	15.25	23.2	20.25	39.2
0.50	0.04	5.50	3.2	10.50	11.4	15.50	23.9	20.50	40.1
0.75	0.07	5.75	3.5	10.75	11.9	15.75	24.6	20.75	41.0
1.00	0.11	6.00	3.8	11.00	12.5	16.00	25.4	21.00	41.9
1.25	0.17	6.25	4.1	11.25	13.0	16.25	26.1	21.25	42.8
1.50	0.24	6.50	5.5	11.50	13.6	16.50	26.9	21.50	43.7
1.75	0.33	6.75	4.8	11.75	14.1	16.75	27.7	21.75	44.6
2.00	0.43	7.00	5.1	12.00	14.7	17.00	28.4	22.00	45.5
2.25	0.54	7.25	5.5	12.25	15.3	17.25	29.2	22.25	46.4
2.50	0.66	7.50	5.9	12.50	15.9	17.50	30.0	22.50	47.4
2.75	0.80	7.75	6.3	12.75	16.5	17.75	30.8	22.75	48.3
3.00	0.96	8.00	6.7	13.00	17.2	18.00	31.6	23.00	49.3
3.25	1.1	8.25	7.1	13.25	17.8	18.25	32.4	23.25	50.2
3.50	1.3	8.50	7.5	13.50	18.4	18.50	33.2	23.50	51.2
3.75	1.5	8.75	8.0	13.75	19.1	18.75	34.1	23.75	52.2
4.00	1.7	9.00	8.4	14.00	19.7	19.00	34.9	24.00	53.1
4.25	1.9	9.25	8.9	14.25	20.4	19.25	35.8	24.25	54.1
4.50	2.1	9.50	9.4	14.50	21.1	19.50	36.6	24.50	55.1
4.75	2.4	9.75	9.9	14.75	21.8	19.75	37.5	24.75	56.1
5.00	2.6	10.00	10.3	15.00	22.5	20.00	38.3	25.00	57.1

7.8   Calculation of the linear tension, T. The linear tension T per unit length is similar to that of a spherical soap bubble, and if p is in kgf/cm² and r is in cm, T is given in kgf/cm by the equation $T = pr/2$. This equation shows that p is not itself a measure of the tension in the leather; for example, a completely inextensible material would have r infinite for all values of p and hence would have to exert an infinitely large linear tension to withstand any pressure.

The value of T in kgf/cm can be found from the equation:

$$T = P \left[\frac{(h^2 + 625)}{40h} \right] = pZ$$

where h is in millimetres, $Z = (h^2 + 625)/40h$, and p is in kgf/cm². To facilitate calculation, corresponding values of h and Z are given in Table 2.

Table 2 Values of the cap height h in millimetres and the corresponding values
of Z

h	Z	h	Z	h	Z	h	Z	h	Z
0.25	62.51	5.25	3.11	10.25	1.781	15.25	1.406	20.25	1.278
0.50	31.26	5.50	2.98	10.50	1.751	15.50	1.396	20.50	1.275
0.75	20.85	5.75	2.86	10.75	1.722	15.75	1.386	20.75	1.271
1.00	15.65	6.00	2.75	11.00	1.695	16.00	1.377	21.00	1.269
1.25	12.53	6.25	2.66	11.25	1.670	16.25	1.368	21.25	1.267
1.50	10.45	6.50	2.57	11.50	1.646	16.50	1.359	21.50	1.264
1.75	8.97	6.75	2.48	11.75	1.624	16.75	1.352	21.75	1.262
2.00	7.86	7.00	2.41	12.00	1.602	17.00	1.344	22.00	1.260
2.25	7.00	7.25	2.34	12.25	1.582	17.25	1.337	22.25	1.258
2.50	6.31	7.50	2.27	12.50	1.563	17.50	1.330	22.50	1.257
2.75	5.75	7.75	2.21	12.75	1.544	17.75	1.324	22.75	1.256
3.00	5.28	8.00	2.15	13.00	1.527	18.00	1.318	23.00	1.254
3.25	4.89	8.25	2.10	13.25	1.510	18.25	1.312	23.25	1.253
3.50	4.55	8.50	2.05	13.50	1.495	18.50	1.307	23.50	1.252
3.75	4.26	8.75	2.00	13.75	1.480	18.75	1.302	23.75	1.252
4.00	4.01	9.00	1.96	14.00	1.466	19.00	1.297	24.00	1.251
4.25	3.78	9.25	1.92	14.25	1.453	19.25	1.293	24.25	1.251
4.50	3.58	9.50	1.88	14.50	1.440	19.50	1.289	24.50	1.250
4.75	3.41	9.75	1.85	14.75	1.428	19.75	1.285	24.75	1.250
5.00	3.25	10.00	1.81	15.00	1.417	20.00	1.281	25.00	1.250

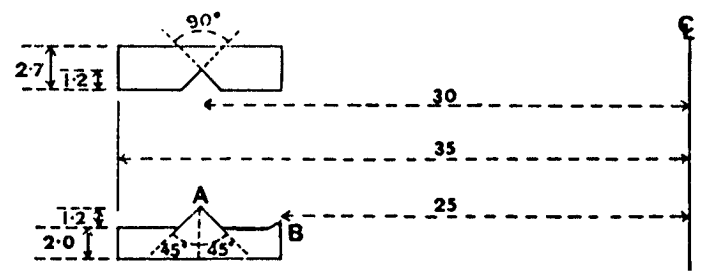7.9   Fig 3 shows a pair of grip rings which have proved satisfactory.

Fig 3   Grip rings
Dimensions in millimetres. The edge of A is rubbed lightly with fine
emery to remove any burring. The ridge at B is 0.1–0.2 mm high

*   A suitable apparatus can be obtained from Bally Shoe Factories Ltd,
Schoenenwerd, Switzerland.