TABLE.1

Relative humidity and temperature inside the shoe with chrome tanned upper.

Room temparature 30-32°C
Room r.h. 48-54%

Region of the foot	Initial Tem. °C.	Initial r.h(%)	Relative humidity and temparature after wear for. 2 hours %rh	2 hours Temp.	4hours %rh.	4hours Temp.	6 hours %rh.	6 hours Temp.	8 hours %r.h.	8 hours Temp.
1.	33.4-33.8		69-80	35.8-36.3	78-86	36.7-37.4	85-91	36.5-37.1	88-93	36.2-36.9
	(33.3-33.7)	50	(68-81)	(35.6-36.2)	(76-84)	(36.5-37.5)	(83-90)	(36.4-37.0)	(86-92)	(36.3-36.8)
2.	33.3-33.7		65-74	36.0-36.8	73-84	36.9-37.7	78-87	36.8-37.5	82-91	36.5-37.3
	(33.1-33.7)	50	(63-73)	(35.9-36.7)	(72-82)	(36.8-37.7)	(78-88)	(36.6-37.3)	(80-90)	(36.4-37.2)
3.	33.6-33.8		54-57	33.9-34.1	57-63	34.1-34.5	58-67	34.0-34.4	60-68	33.9-34.2
	(33.5-33.7)	50	(53-55)	(33.9-34.0)	(55-64)	(34.2-34.4)	(56-68)	(33.9-34.3)	(59-69)	(33.7-34.1)
4.	33.0-33.5		74-84	35.5-36.3	83-89	36.4-36.9	89-93	36.0-36.7	90-96	35.5-36.4
	(32.8-33.4)	50	(72-85)	(35.4-36.2)	(81-88)	(36.5-36.8)	(87-93)	(36.0-36.6)	(91-95)	(35.3-36.5)
5.	34.0-34.6		64-74	36.2-36.9	70-80	37.3-38.3	74-85	37.1-38.0	78-88	36.8-37.8
	(34.0-34.4)	50	(65-74)	(36.1-37.0)	(69-78)	(37.2-38.4)	(72-83)	(37.0-37.8)	(76-86)	(36.6-37.7)

Type of shoes - Derby
Upper - chrome tanned upper (Protein finish)

Lining - E.I.Goat
Insole - E.I.Goat
Sole - Vegetable tanned sole le-ather.

Figures are for the left foot and these in parenthesis are for the fight foot.

The range of valves for r.h. and temparature are for 30 subjects.

TABLE.2

Relative humidity and temperature inside the leather shoe with chrome retanned upper.

Room temparature 30-32°C
Room r.h. - 48-54%

Region of the foot	Initial Temp. °C	Initial r.h(%)	Relative humidity and temparature after the wear for 2hrs %r.h.	2hrs Temp.	4hrs %r.h.	4hrs Temp.	6hrs. %r.h.	6hrs. Temp.	8hrs. %r.h.	8hrs. Temp.
1.	33.1-33.8		71-81	36.0-36.5	81-88	36.9-37.7	88-92	36.7-37.5	90.95	36.5-37.3
	(33.3-33.7)	50	(70-82)	(36.1-36.7)	(81-87)	(36.8-37.7)	(87-91)	(36.8-37.6)	(89-94)	(36.6-37.4)
2.	33.3-33.7		67-76	36.2-37.1	76-86	37.1-38.1	80-89	36.9-37.8	85-94	36.7-37.6
	(33.1-33.7)	50	(66-75)	(36.1-37.0)	(76-86)	(37.1-38.1)	(79-89)	(37.0-38.0)	(84-92)	(36.8-37.7)
3.	33.0-33.3		56-58	34.0-34.4	60-65	34.2-34.6	61-70	34.1-34.5	64-74	34.0-34.3
	(33.5-33.7)	50	(55-58)	(34.0-34.3)	(59-66)	(34.2-34.5)	(60-69)	(34.1-34.4)	(63-72)	(33.9-34.3)
4.	33.0-33.5		76-86	35.7-36.5	84-91	36.6-37.1	90-94	36.3-36.9	94-96	36.0-36.7
	(32.8-33.4)	50	(75-86)	(35.5-36.4)	(84-90)	(36.4-37.0)	(90-94)	(36.2-36.9)	(94-96)	(35.9-36.7)
5.	34.0-34.6		66-78	36.4-37.1	72-84	37.6-38.6	76-87	37.3-38.4	81-92	37.1-38.1
	(34.0-34.4)	50	(67-78)	(36.2-37.0)	(72-83)	(37.4-38.5)	(75-86)	(37.2-38.4)	(80-92)	(37.1-37.9)

Type of shoes - Derby
Upper - chrome retanned upper (Resin finish)

Linning - E.I.Goat.
Inside - E.I.Goat.
Sole - Vegetable tanned sole leather

Figures are for the left foot and those in the paranthesis are for the right foot.

The range of ~~[illegible]~~ for r.h& temparature are for 30 subjects

TABLE.5

Relative humidity and temperature inside the new leather shoes (short liming).

Room temparature 30-32°C
Room r.h. 48-54%

Region of the foot	Initial Temp. °C	Initial r.h.%	Relative humidity and temparature after wear for 2hrs. %r.h.	2hrs. Temp.	4hrs %r.h.	4hrs Temp.	6hrs %rh.	6hrs Temp.	8hrs. %rh.	8hrs. Temp.
1.	33.4-33.8 (33.3-33.7)	50	69-81 (69-80)	35.8-36.3 (35.7-36.3)	78-85 (77-85)	36.7-37.4 (36.5-37.5)	85-91 (84-91)	36.5-37.2 (36.5-37.1)	88-93 (88-92)	36.3-36.9 (36.3-36.9)
2.	33.3-33.7 (33.1-33.7)	50	65-74 (64-73)	36.0-36.9 (35.9-36.8)	73-84 (72-84)	36.9-37.7 (36.9-37.8)	78-88 (77-88)	36.7-37.6 (36.7-37.5)	82-91 (81-90)	36.5-37.4 (36.5-37.4)
3.	33.6-33.8 (33.5-33.7)	50	54-57 (54-56)	33.9-34.1 (33.9-34.0)	56-64 (57-64)	34.2-34.5 (34.1-34.5)	58-68 (58-67)	34.0-34.4 (33.9-34.4)	60-69 (60-69)	33.9-34.2 (33.8-34.2)
4.	33.0-33.5 (32.8-33.4)	50	74-85 (74-84)	35.5-36.3 (35.4-36.3)	83-88 (82-88)	36.5-36.9 (36.4-36.8)	89-93 (88-93)	36.1-36.7 (36.0-36.6)	91-96 (91-95)	35.5-36.5 (35.4-36.5)
5.	34.0-34.6 (34.0-34.4)	50	61-74 (61.5-74	36.2-37.0 (36.2-37.0	70-79 (70-80)	37.3-38.4 (37.3-38.3)	74-85 (73-84)	37.1-38.0 (37.0-37.9)	78-88 (77-87)	36.8-37.8 (36.8-37.7)

Type of shoes : Derby
Upper : Chrome tanned upper (short liming) (protein finish)
Linning: F.I.Goat
Insole : F.I.Goat
Sole : Vegetable tanned sole leather.

Figures are for the left foot and those in the paranthesis are for the right foot.

The range of values for r.h and temperature are for 30 subjects.

TABLE.6

Relative humidity and temperature inside the old leather shoes(6 months after use)

Room temparature 30-32°C
Room r.h. 48-54%

Region of the foot	Initial Temp. °C	Initial r.h %	Relative humidity and temparature after wear for. 2hrs %rh	2hrs Temp.	4hrs %r.h	4hrs Temp.	6hrs %rh	6hrs Temp.	8hrs %rh.	8hrs Temp.
1.	33.4-33.8		58-64	35.5-36.0	67-72	36.3-37.0	73-78	36.0-36.7	75-82	35.8-36.4
	(33.3-33.7)	50	(59-65)	(35.4-35.9)	(68-71)	(36.2-37.0)	(72-76)	(36.0-36.6)	(74-80)	(35.7-36.3)
2.	33.3-33.7		55-59	35.6-36.3	63-69	36.4-37.5	67-75	36.2-37.1	70-81	35.9-36.8
	(33.1-33.7)	50	(54-59)	(35.5-36.2)	(62-68)	(36.3-37.4)	(66-73)	(36.1-37.2)	(69-80)	(35.8-36.7)
3.	33.6-33.8		54-55	33.8-34.0	56-60	33.9-34.1	57-64	33.5-33.7	58-66	33.3-33.5
	(33.5-33.7)	50	(53-55)	(33.7-33.9)	(55-58)	(33.8-34.2)	(57-65)	(33.4-33.6)	(58-67)	(33.2-33.4)
4.	33.0-33.5		63-70	35.3-36.0	72-77	35.9-36.3	80-84	35.7-36.3	82-88	35.5-36.1
	(32.8-33.4)	50	(62-68)	(35.2-35.8)	(72-78)	35.8-36.4	(78-82)	(35.6-36.1)	(80-87)	(35.3-35.8)
5.	34.0-34.6		54-58	35.9-36.5	60-65	37.0-37.9	65-72	36.8-37.6	67-76	36.6-37.4
	(34.0-34.4)	50	(55-59)	(35.8-36.4)	(59-63)	(36.8-37.7)	(64-70)	(36.7-37.5)	(65-75)	(36.5-37.3)

Type of shoes - Derby
Upper - Chrome tanned upper (protein finish)
Linning - E.I.Goat
Insole - E.I.Goat
Sole - Vegetable tanned sole leather.

Figures are for the left foot and those in paranthesis are for the right foot.

The range of values for relative humidity and temperature are for 30 subjects.

TABLE.7

Relative humidity and temperature inside the shoe with chrome tanned upper and with impermeable plastic socks over nylon socks.

Room temparature 30–32°C
Room r.h. 48–54%

Region of the foot	Initial temparature °C.	Initial	Relative humidity and temparature after wear for 2 hours	
			% r.h.*	Temparature
1.	33.4 – 33.3 (33.3 – 33.7)	50	100	39.6 – 41.2 (39.5 – 41.3)
2.	33.3 – 33.7 (33.1 – 33.7)	50	100	39.1 – 40.7 (39.0 – 40.5)
3.	33.3 – 33.8 33.5 – 33.7	50	100	37.5 – 39.4 (37.6 – 39.4)
4.	33.0 – 33.5 (32.8 – 33.4)	50	100	38.2 – 40.2 (38.2 – 40.1)
5.	34.0 – 34.6 (34.0 – 34.4)	50	100	40.0 – 41.7 (40.0 – 41.7)

Type of shoe – Derby
Upper – Chrome tanned upper (protein finish)
Linning – E.I.Goat
Insole – E.I.Goat

* perspiration condensed on the plastic impermeable socks. Figures are for the left foot and these in paranthesis are for the right foot. The range for values for r.h. and temperature are for 30 subjects.

TABLE. 8

Feeling of comfort in shoes at various periods of wear. Room Temp. 30-32°C
Room r.h. 48-54%

Type of upper.	Period of wear			
	2 hours	4 hours	6 hours	8 hours.
Chrome tanned upper (protein finish)	Comfortable	Comfortable	Comfortable	Confortable
Chrome retanned upper (resin finish)	Comfortable	Comfortable	Uncomfortable to some subjects	Uncomfortable to some subjects
Chrome tanned upper (protein finish) Rubber sole	Comf ortable	Uncomfortable to some subjects	Uncomfortable to most of the subjects	Uncomfortable to all the subjects
Chrome tanned upper (protein finish) (with impermeable socks)	Uncomfortable to all subjects			

TABLE.9

Temperature Humidity index (I_{TH}) for shoes with chrome tanned upper.

Region of the foot.	I_{TH} after wear for. 2 hours	4 hours	6 hours	8 hours
1.	88.4 - 89.8	91.0 - 93.0	91.0 - 91.8	91.4 - 92.6
2.	87.6 - 90.2	91.0 - 93.0	90.2 - 91.4	91.4 - 93.0
3.	83.4 - 83.9	83.8 - 85.8	84.2 - 84.6	84.2 - 86.2
4.	88.6 - 90.2	91.2 - 93.0	91.0 - 92.6	90.2 - 91.4
5.	87.8 - 89.8	90.6 - 93.0	90.6 - 93.4	90.2 - 93.4

TABLE.10

Temperature Humidity index (I_{TH}) for shoes with chrome retanned upper

Region of the foot	I_{TH} after wear for.			
	2 hours	4 hours	6 hours	8 hours
1.	88.5 - 91.1	91.5 - 93.7	91.4 - 93.6	92.0 - 93.8
2.	89.0 - 90.6	91.3 - 93.5	91.2 - 93.8	91.6 - 94.2
3.	83.9 - 84.9	84.6 - 86.0	84.7 - 86.5	84.8 - 89.2
4.	89.1 - 91.3	91.4 - 92.5	91.4 - 93.0	91.7 - 93.0
5.	88.4 - 91.3	91.4 - 93.2	91.8 - 94.2	91.7 - 94.2

TABLE.11

Temper ture humidity index (I_{TH}) for shoes with rubber soles in wear.

Region of the foot	I_{TH} after wear for. 2 hours	4 hours	6 hours	8 hours
1.	89.0 - 91.8	92.2 - 93.8	93.8 - 95.0	95.0 - 96.2
2.	89.6 - 91.4	92.2 - 93.6	93.8 - 95.1	95.2 - 96.4
3.	84.1 - 85.0	85.8 - 86.6	86.2 - 86.8	86.7 - 89.9
4.	89.4 - 91.8	91.4 - 93.8	92.2 - 94.6	94.6 - 95.0
5.	91.1 - 92.2	91.4 - 93.8	93.4 - 95.8	94.8 - 97.8

TABLE.12

Temperature humidity index (I_{TH}) for old leather shoes in wear
(After use for 6 months)

Region of the foot	I_{TH} after wear for. 2 hours	4 hours	6 hours	8 hours
1.	86.2 - 87.4	88.4 - 90.6	89.0 - 90.8	89.0 - 90.2
2.	86.2 - 87.0	88.2 - 90.8	89.0 - 91.0	89.0 - 91.4
3.	83.4 - 83.6	84.2 - 85.0	83.8 - 84.7	83.4 - 85.0
4.	86.6 - 88.1	87.8 - 90.6	89.4 - 90.8	89.4 - 90.4
5.	86.6 - 87.0	89.8 - 90.6	89.4 - 90.6	89.4 - 91.8

TABLE 13

Temperature Humidity index (I_{th}) for shoes with plastic socks over nylon socks.

Region of the ffot	I_{th} after wear for 2 hours.
1.	97.6 - 99.5
2.	98.9 - 99.2
3.	93.7 - 97.3
4.	95.6 - 98.5
5.	98.2 - 100.9

TABLE.14

Relative humidity and temperature inside the leather shoes with chrome tanned upper in cold climate.

Room temparature 24-26°C
Room r.h 47-52%

Region of the foot	Initial Temp. °C	Initial r.h%	Relative humidity and temparature after wear for 2hrs %r.h.	2hrs Temp.	4hrs %rh.	4hrs Temp.	6hrs %rh.	6hrs Temp.	8hrs %r.h.	8hrs Temp.
1.	33.4-33.7		65-74	31.6-31.1	70-80	31.3-30.7	76-84	31.0-30.4	80-88	29.6-29.1
	(32.8-33.1)	50	(64-73)	(31.5-31.0)	(69-80)	(31.2-30.6)	(75-83)	(30.8-30.3)	(79-87)	(29.4-29.0)
2.	33.2-33.5		62-71	31.7-31.3	68-78	31.5-31.0	72-81	31.2-30.7	77-84	31.0-30.2
	(33.1-33.5)	50	(61-70)	(31.6-31.2)	(67-76)	(31.4-30.8)	(71-80)	(31.0-30.6)	(76-83)	(30.8-30.1)
3.	33.5-33.8		55-56	31.3-31.0	56-58	31.0-30.7	58-63	30.5-30.0	59-65	30.0-29.5
	(33.4-33.8)	50	(54-56)	(31.2-30.8)	(56-58)	(30.9-30.6)	(58-62)	(30.4-30.1)	(60-64)	(29.8-29.4)
4.	33.0-33.4		70-79	31.4-31.0	78-83	31.0-29.6	82-87	30.7-29.3	84-90	30.3-29.1
	(32.8-33.4)	50	(69-77)	(31.3-30.8)	(77-82)	(29.8-29.5)	(80-86)	(30.6-29.1)	(83-88)	(30.2-29.0)
5.	34.0-34.5		60-69	31.8-31.4	65-73	31.5-31.0	70-81	31.2-30.7	73-85	31.0-30.5
	(34.0-34.4)	50	(58-67)	(31.7-31.4)	(64-72)	(31.4-30.8)	(68-80)	(31.1-30.6)	72-84	(30.9-30.3)

Type of shoes - Derby
Upper - chrome tanner upper
Linning - E.I. Goat
Insole - F.I. Goat
Sole - Vegetable tanned sole leather.

Figures are for the left foot and these in the paranthesis are for the right foot.
The range of values for r.h. and temperature are for 20 subjects.

TABLE.15

Relative humidity and temperature inside the leather shoes with chrome tanned upper in cold climate.

Room temparature 22-25°C
Room r.h. 25-30%

Region of the foot	Initial Temp. °C	Initial r.h.%	Relative humidity and temparature after wear for. 2hrs %r.h.	2hrs Temp.	4hrs %r.h.	4hrs Temp.	6hrs %r.h.	6hrs Temp.	8hrs %r.h.	8hrs Temp.
1.	33.4-33.7		62-71	30.4-29.8	69-76	28.5-27.8	72-80	27.6-27.0	74-84	26.8-26.2
	(33.3-33.7)	50	(61-70)	(30.3-29.6)	(68-76)	(28.4-27.7)	(71-79)	(27.5-26.8)	(73-82)	(26.6-26.1)
2.	33.2-33.5		59-68	30.7-30.3	64-72	29.2-28.5	68-75	28.2-27.5	70-79	27.3-26.9
	(33.1-33.6)	50	(59-67)	(30.6-30.2)	(63-71)	(29.1-28.3)	(68-74)	(28.1-27.4)	(69-78)	(27.1-26.8)
3.	33.6-33.8		52-54	30.2-29.5	54-56	28.1-27.2	57-60	27.0-26.4	60-63	26.1-25.7
	(33.4-33.8)	50	(52-54)	(30.1-29.4)	(54-56)	(28.0-27.1)	(56-59)	(26.9-26.2)	(60-62)	(26.0-25.5)
4.	33.0-33.4		65-75	30.5-30.1	72-78	28.7-28.0	76-82	27.8-27.3	78-86	27.0-26.5
	(32.8-33.4)	50	(64-73)	(30.4-30.2)	(72-77)	(28.6-27.9)	(75-81)	(27.7-27.1)	(78-85)	(26.9-26.4)
5.	34.0-34.5		57-66	31.1-30.6	62-69	29.6-29.0	66-74	28.7-28.0	69-76	27.8-27.1
	(34.0-34.4)	50	(56-65)	(31.0-30.5)	(61-67)	(29.4-28.9)	(65-73)	(28.6-27.8)	(68-75)	(27.6-27.0)

Type of shoes - Derby
Upper - chrome tanned upper
Linning - E.I.Goat
Insole - E.I.Goat
Sole - Vegetable tanned sole leather.

Figures are for the left foot and those in the paranthesis are for the right foot.
The range of values for r.h. and temparature are for 20 subjects

TABLE 66

Relative humidity and temperature inside the leather shoes with chrome tanned upper in cold climate.

Room temparature 15-17°C
Room r.h. - 54-59%

Region of the foot	Initial Temp. °C	Initial r.h%	Relative humidity and temparature after wear for. 2hrs %r.h	2hrs Temp	4hrs %r.h	4hrs Temp	6hrs %r.h	6hrs Temp	8hrs %r.h	8hrs Temp
1.	33.4-33.7	58-64	27.1-26.6	64-69	23.4-22.8	68-75	18.5-18.0	73-79	18.0-17.6	
	(33.3-33.7)	50 (57-63)	(27.0-26.5)	(63-68)	(23.2-22.7)	(67-74)	(18.4-17.9)	(72-77)	(17.8-17.5)	
2.	33.2-33.5	56-60	26.7-26.3	60-66	23.0-22.5	63-70	18.1-17.8	66-73	17.7-17.4	
	(33.1-33.6)	50 (55-60)	(26.6-26.2)	(59-66)	(22.9-22.4)	(62-69)	(18.0-17.6)	(65-73)	(17.6-17.3)	
3.	33.5-33.8	54-57	26.4-26.0	57-60	22.5-22.0	60-63	17.8-17.5	62-65	17.5-17.2	
	(33.4-33.6)	50 (54-57)	(26.3-25.9)	(56-59)	(22.4-21.9)	(59-62)	(17.8-17.4)	(61-64)	(17.5-17.2)	
4.	33.0-33.4	62-70	26.6-26.2	66-75	22.7-22.0	69-77	18.2-17.8	73-81	17.6-17.3	
	(32.9-33.3)	50 (61-68)	(26.5-26.2)	(66-73)	(22.5-21.9)	(68-76)	(18.1-17.7)	(72-80)	(17.5-17.2)	
5.	34.0-34.5	58-63	27.8-27.1	63-68	23.8-23.1	66-71	19.0-18.5	70-76	18.4-17.9	
	(33.9-34.4)	50 (57-62)	(27.6-27.0)	(62-67)	(23.7-23.0)	(65-70)	(18.8-18.4)	(69-75)	(18.3-17.8)	

Type of shoes - Derby
Linning - E.I.Goat
Upper - chrome tanned upper

Insole - F.I.Goat
Sole- Vegetable tanned sole leather.

Figures are for the left foot and those in the paranthesis are for the right foot.

The range of values for r.h. and temperature are for 20 objects.

TABLE.17

Relative humidity and temperature inside the leather shoes with chrome tanned upper in cold climate.

Room temparature 12-15°C
Room r.h 46-52%

Region of the foot	Initial Temp. °C	Initial %r.h	Relative humidity and temperature after wear for. 2hrs %r.h	2hrs Temp	4hrs %r.h	4hrs Temp.	6hrs %r.h	6hrs Temp	8hrs %r.h	8hrs Temp.
1.	33.4-33.7 (33.3-33.7)	50	56-62 (55-62)	26.2-25.7 (26.1-25.6)	60-65 (60-64)	22.6-22.1 (22.5-22.1)	63-70 (62-69)	18.0-17.4 (17.9-17.3)	68-74 (67-72)	17.2-16.8 (17.1-16.8)
2.	33.2-33.5 (33.1-33.6)	50	54-58 (54-57)	25.8-25.4 (25.7-25.4)	58-62 (57-61)	22.1-21.7 (22.0-21.6)	60-66 (60-65)	17.6-17.1 (17.5-17.0)	63-69 (62-68)	16.9-16.3 (16.8-16.2)
3.	33.5-33.8 (33.4-33.6)	50	52-54 (52-54)	25.2-24.7 (25.1-24.6)	54-56 (54-57)	21.3-20.8 (21.2-20.6)	56-59 (56-59)	16.7-16.2 (16.5-16.1)	59-62 (58-61)	16.1-15.7 (16.0-15.6)
4.	33.0-33.4 (32.9-33.3)	50	59-67 (58-66)	25.5-25.0 (25.5-24.9)	63-70 (61-69)	21.6-21.1 (21.5-21.0)	66-74 (65-72)	17.8-17.3 (17.7-17.2)	68-77 (68-76)	17.0-16.6 (16.8-16.5)
5.	34.0-34.5 (33.9-34.4)	50	55-60 (54-59)	26.7-26.1 (26.6-26.1)	59-63 (59-62)	22.6-22.0 (22.5-21.8)	62-69 (61-68)	18.2-17.6 (18.1-17.5)	66-72 (64-71)	17.5-17.1 (17.4-17.0)

Type of shoes : Derby
Upper - Chrome tanned upper
Linning- E.I.Goat
Insole E.I.Goat
Sole - Vegetable tanned sole leather.

Figures are for the left ffot and those in the paranthesis are for the fight foot.

The range of valves for r.h and temperature are for 20 subjects.

TABLE.18

Relative humidity and temperature inside the shoe with chrome tanned upper and with impermeable plastic socks over nylon socks.

Room temparature 12-15°C
Room r.h. 46-52%

Region of the foot.	Initial Tem. °C.	Initial r.h. %	Relative humidity and temparature after wear for. 2hrs.* %r.h.	Temp	4hrs.* %r.h	Tem.
1.	33.4-33.7 (33.3-33.7)	50	100	20.1-19.7	100	16.0-15.5
2.	33.2-33.5 (33.1-33.6)	50	100	19.8-19.2	100	15.8-15.4
3.	33.5-33.8 (33.4-33.6)	50	100	19.2-18.6	100	15.4-15.0
4.	33.0-33.4 (32.9-33.3)	50	100	19.5-19.1	100	15.6-15.2
5.	34.0-34.5 (33.9-34.4)	50	100	20.5-19.9	100	16.3-15.7

Type of shoe Derby
Upper chrome tanned upper (protein finish)
Linning E.I.Goat
Insole E.I.Goat
Sole vegetable tanned sole leather.

* Perspiration condensed on the plastic impermeable socks. Figures are for the left foot and these in paranthesis are for the right foot. The range of valves for r.h. and temparature are for 20 subjects.

TABLE.19

Temperature Humidity Index (ITH) in cold climate for shoes with chrome tanned upper.

Room temparature 24-26°C
Room r.h. 47-52%

Region of the foot.	ITH after wear for. 2 hours	4 hours	6 hours	8 hours.
1.	81.8 - 82.4	82.4 - 82.7	82.9 - 82.9	80.7 - 80.8
2.	80.8 - 82.4	82.1 - 81.9	82.5 - 82.7	82.9 - 82.2
3.	80.2 - 80.1	80.1 - 79.0	79.4 - 79.8	78.9 - 78.5
4.	82.4 - 82.9	82.9 - 81.0	83.8 - 81.5	82.3 - 81.1
5.	81.4 - 82.4	81.7 - 82.3	82.2 - 82.5	82.5 - 82.8

TABLE. 20

Temperature Humidity index (ITH) in cold climate for shoe with chrome tanned upper.

Room temperature 22-25°C
Room r.h. 25-30%

Region of the foot	ITH after wear for. 2 hours	4 hours	6 hours	8 hours
1.	80.0 - 80.5	79.9 - 78.2	77.5 - 77.2	76.4 - 76.6
2.	79.7 - 80.6	78.4 - 78.1	77.6 - 77.2	76.4 - 77.2
3.	78.4 - 77.6	75.8 - 75.4	74.8 - 74.6	74.1 - 73.9
4.	80.4 - 81.3	78.5 - 78.6	78.2 - 78.5	77.4 - 77.5
5.	80.5 - 80.4	78.7 - 79.1	78.3 - 77.9	77.4 - 77.1

TABLE. 21

Temperature Humidity index (ITH) in cold climate for shoes with chrome tanned upper.

Room temperature 15-17°C
Room r.h. 54-59%

Region of the foot	ITH-after wear for 2 hours	4 hours	6 hours	8 hours.
1.	75.0 - 73.3	71.0 - 70.6	64.5 - 64.4	64.2 - 64.4
2.	74.6 - 74.3	70.0 - 69.2	63.3 - 64.5	63.6 - 63.2
3.	74.0 - 73.7	68.8 - 68.6	63.7 - 63.3	63.3 - 63.6
4.	75.2 - 75.2	70.2 - 70.2	64.4 - 65.1	63.6 - 63.8
5.	74.3 - 74.2	69.5 - 68.8	65.0 - 64.7	64.6 - 64.4

TABLE.22

Temperature Humidity index (ITH) in cold climate for shoes with chrome tanned upper.

Room temperature 12-15°C
Room r.h. 46-52%

Region of the foot	ITH after wear for. 2 hours	4 hours	6 hours	8 hours
1.	73.8 - 73.2	69.5 - 69.3	63.4 - 63.0	62.8 - 62.4
2.	72.9 - 73.0	68.5 - 68.4	62.5 - 62.5	62.0 - 61.4
3.	72.0 - 71.6	68.4 - 68.4	61.4 - 60.5	60.6 - 60.2
4.	73.4 - 73.3	68.3 - 68.4	62.1 - 63.4	62.4 - 63.0
5.	74.3 - 74.2	69.5 - 68.8	63.3 - 63.2	63.0 - 62.4

TABLE. 23

Temperature Humidity index (ITH) in cold climate for shoes with chrome tanned upper and with plastic socks over nylon socks.

Room temperature 12-15°C
Room r.h. 46-52%

Region of the foot	ITH after wear for 2 hours	ITH after wear for 4 hours
1.	69.6 - 69.0	63.6 - 62.8
2.	69.1 - 68.2	63.3 - 62.8
3.	68.2 - 67.3	62.7 - 62.2
4.	68.7 - 68.1	63.0 - 62.5
5.	70.1 - 69.3	64.1 - 63.2

TABLE. 24

Effect of cold climate on relative humidity and temperature inside the shoe with chrome upper leather.

Room temperature 4°C
Room r.h. 50 ± 2%

Region of the foot.	Initial Temperature °C	Initial r.h %	Temperature after wear for 15 minutes	½ hour	1 hour	2 hour	r.h. inside the shoe after 2hrs wear.
1.	33.4–35.8 (33.3–33.7)	50	26.0–25.8 (26.1–25.8)	23.3–23.0 (23.2–23.0)	19.5–19.2 (19.4–19.1)	15.4–15.1 (15.3–15.1)	50
2.	33.3–33.7 (35.1–35.7)	50	25.9–25.6 (25.8–25.5)	23.1–22.7 (23.1–22.6)	19.2–18.8 (19.1–18.6)	15.0–14.7 (14.9–14.6)	50
3.	33.6–33.8 (33.6–33.7)	50	25.4–25.1 (25.3–25.0)	22.4–22.2 (22.3–22.0)	18.4–18.1 (18.3–18.0)	14.3–13.8 (14.2–13.7)	50
4.	33.0–33.5 (32.8–33.4)	50	25.8–25.6 (25.8–25.5)	22.9–22.6 (22.8–22.5)	19.0–18.6 (18.9–18.7)	14.9–14.5 (14.8–14.6)	50
5.	34.0–34.0 (34.0–34.4)	50	26.6–26.2 (26.5–26.2)	23.7–23.3 (23.6–23.3)	19.9–19.5 (19.9–19.6)	15.6–15.2 (15.5–15.2)	50

Type of shoe Derby
Upper – chrome tanned upper (protein finish)
Linning – E.I. Goat
Insole – E.I. Goat
Sole – vegetable tanned sole leather.

Figures are for the left foot and those in the paranthesis are for the right foot.
The ranged values for r.h and temperature are for 30 subjects.

TABLE. 25

Temperature Humidity index (ITH) in cold climate for shoes with chrome tanned upper.

Region of the foot	ITH after wear for			
	15 mts	½ hour	1 hour	2 hours
1.	72.9	70.8	64.2	58.9
2.	72.6	69.4	64.2	58.4
3.	71.9	68.0	62.8	57.5
4.	72.0	68.6	63.4	58.1
5.	73.8	69.8	64.9	61.3

TABLE 26

Water vapour permeability and water vapour absorption of chrome tanned (short and long liming) upper in combination with E.I.goat.

Type of combination.	Property	Time 1 hr	2hrs	4hrs	6hrs	8hrs
Chrome tanned upper (long liming) + E.I.goat	Water vapour absorption mgm/sq.cm	15.1	22.4	32.8	41.6	47.9
Chrome tanned upper (short liming) + E.I. goat.	-do-	15.0	22.2	32.1	40.9	47.3
Chrome tanned upper (long liming) + E.I. goat	Water vapour permeability mgm/sq cm/hr	10.21				
Chrome tanned upper (short liming) + E.I. goat.	-do-	7.93				

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Section V:

Fungi in Footwear

One of the functions of footwear is to protect the foot from the microbial contaminations of the surroundings. It is known that tan liquors, tanning materials and leathers support the fungal growth.[1-11] Hence it is possible that footwear made of such leathers may contain various species of the fungi. The fungi present in footwear may also depend upon the place where it is worn and the climatic conditions of the place.

It can be seen from Table 1 that the most common fungi that are present in footwear are A. niger and A. fumigatus. In addition to these, in men's shoes, penicillium type, A. sydowi and A. japonicus are also found fairly frequently. In men's sandals Penicillium type and A.nidulans are also quite frequent. In women's sandals, A. japonicus, A. flavus and A. nidulans are quite frequent. However, the table clearly shows A. niger and A. fumigatus are the most important species that are commonly found in men's and women's footwear.

Table 2 shows the growth of fungi on water solubles of leather. It is observed that the water solubles from vegetable tanned leathers support the growth of fungi better than the water solubles from retanned leathers. This may be due to the fact that amount of water solubles is less in retanned leathers as compared to vegetable tanned leathers.

(Table 3). Therefore, it can be said that the water solubles of leather are one of the main sources of nutrient for fungal growth.

Table 2 also shows the growth of fungi on the sweat solubles of leather. It is observed that the perspiration solubles support the mould growth better than the water solubles. This may be due to the nitrogenous material and mineral ions in addition to the usual solubles of leather. This may indicate more growth of fungi in worn shoes under favourable conditions, since the constituents of sweat can accumulate in them.

Thus it may be observed that the fungi which can grow on leather is of objectionable character if for no other reasons than the aesthetic value of footwear. The most common fungi that can grow on the footwear are A.niger and A. fumigatus. Therefore, to make the footwear more attractive and hygienic, the prevention of the growth of these fungi has to be effected using fungicides or any other suitable method.

Table.1

Occurance of various fungi in men's and women's foot wear (Figures are ratios of the number of cases where the fungus was present to the total number observed expressed as percentage)

Type of fungi	Men's shoes (17 individuals)	Men's sandals (5individuals)	Womens sandals (3 individuals)
A.niger	82	100	100
A.fumigatus	76	100	67
A.terreus	18	-	-
A.sydowi	35	-	-
A.japonicus	24	-	33
A.flavus	6	-	33
A.nidulaus	12	40	33
Pacitimycesvarioti	6	-	-
Penicillium type	35	20	-
Alternaria	6	6	-

Table.2

Growth of fungi on water solubles and sweat solubles of leathers (mat wt. in mgm.)

Sample	A. niger		A.fumigatus		Penicillium type	
	W	S	W	S	W	S
Sole leather	16.0	29.2	15.8	39.2	16.7	19.4
E.I. goat	16.7	29.8	12.3	17.8	14.8	17.0
E.I. sheep	18.4	31.3	14.2	26.4	13.4	16.1
Chrome retanned with cutch.	10.8	14.4	10.7	16.0	10.1	16.4
Chrome retanned with wattle	10.2	14.7	10.1	15.1	8.7	13.4

W: Water solubles of leathers.

S: Sweat solubles of leathers.

Table.3

Total solubles in water solubles of leathers (% on weight of the leather)

Type of leather	% water solubles
Sole leather (veg.tanned)	11.0
E.I. goat	6.27
E.I. sheep	10.08
Chrome retanned with cutch	3.9
Chrome retanned with wattle	1.61

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Section VI:

Chemical properties of leather that contribute to comfort in wear.

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When leather is worn as shoe, the main constituent which can accumulate in it is the human perspiration coming out from the foot. Therefore, footwear to be comfortable, should try to maintain the pH of the surroundings of the foot at the pH of the skin so that the footwear is compatible to the skin. Though the pH of human sweat is mostly in the acidic side[1], the decomposition of the sweat by microorganisms, with the production of ammonia, may change the pH tothe alkaline side. In addition, some have their sweat orginally in the alkaline side with a maximum pH of 7.8[2]. Hence, leather, to be compatable to skin, should try to maintain the pH nearer to the pH of the skin. Since vegetable tanned leathers and retanned leathers contain soluble materials, the so called 'water solubles' may help to maintain the pH of the leather near the pH of the skin. Due to the constant friction between the footwear and the skin, there is a possibility that the debris of the skin may accumulate inside the shoe. It is known that even by rubbing the fingers in water a fine dispersion of epidermis is produced.[3] In normal conditions, these debris may putrify and may support the growth of bacteria. Since leather, especially lining, sole and retanned leathers contain water solubles, the skin debris may

get tanned and become resistant to the attack of microorganisms. Therefore, the buffering action and tanning action of water solubles of leathers was studied.

Fig.3 shows that the water solubles from vegetable tanned lining leathers such as E.I.goat and E.I. sheep leathers, vegetable tanned sole leather as well as chrome retanned leathers have buffering action. It is also observed that the buffering action follows the following order.

Sole Leather E.I.Shoop E.I.Goat Chrome retan

It is observed elsewhere that the percent water solubles of sole leather is the highest and the percent water solubles of chrome retanned leather is the lowest. The values for E.I. goat and E.I. sheep are in between the values for sole and chrome retanned leathers. Therefore, the capacity of the buffering action depends upon the amount of water solubles in leather though other factors like type of tanning material and presence of other nontanning materials may also play a part in the buffering action. This buffering action may be responsible for the compatibility of the leather with the skin.

It is observed from Table 1 that water solubles from sole leather, lining leather viz. E.I. goat and E.I. sheep and also from retanned leather can tan and stabilise collagen. The maximum stability, as

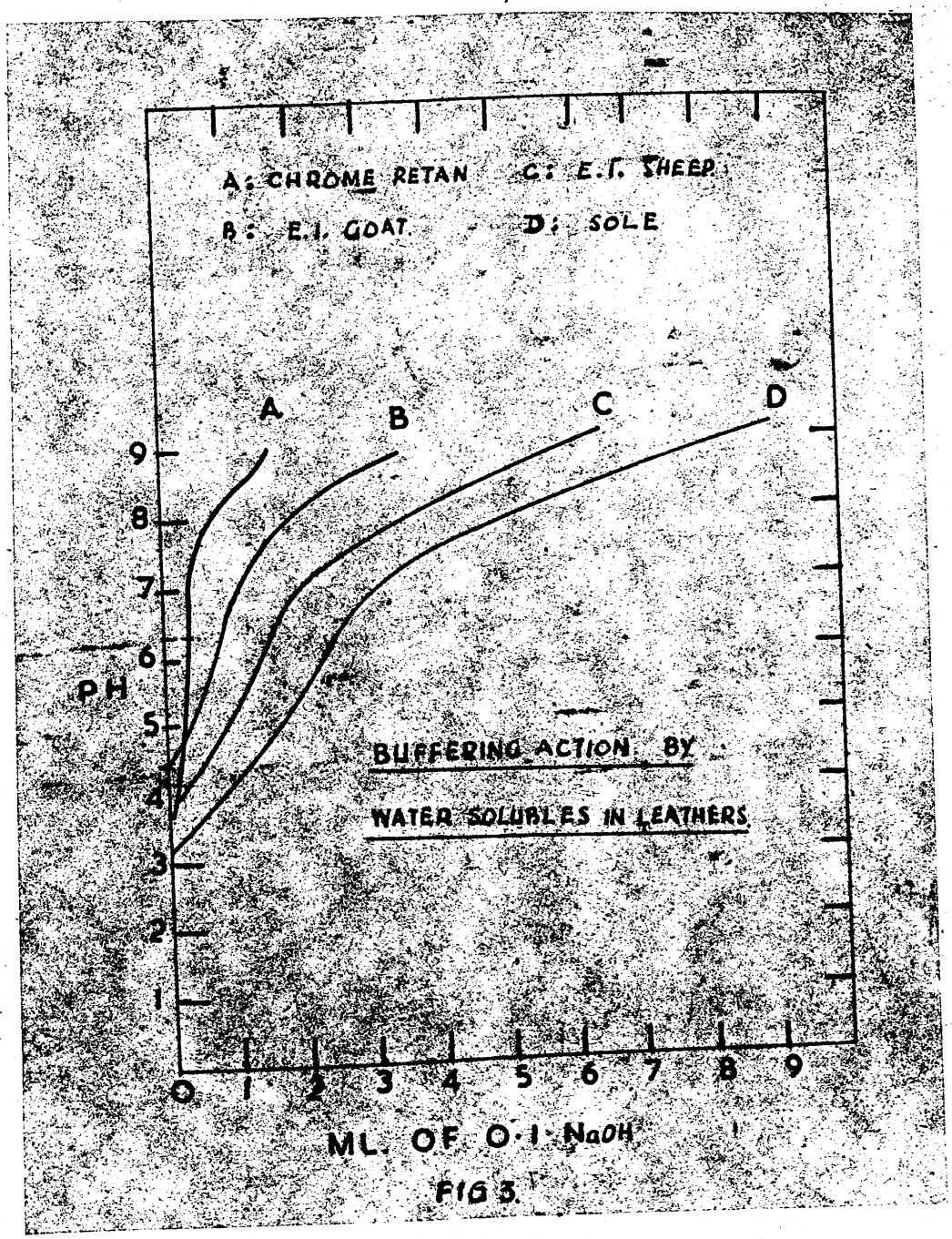
A: CHROME RETAN
C: E.T. SHEEP
B: E.I. GOAT
D: SOLE
A
B
C
D
PH
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
BUFFERING ACTION BY
WATER SOLUBLES IN LEATHERS
ML. OF 0·1 NaOH

FIG 3.

determined by the shrinkage temperature of the leather is imparted by water solubles of sole leather. The water solubles from E.I. goat and E.I. sheep impart almost the same amount of stability. The water solubles from retanned leather stabilise the collagen to a smaller extent. Table 2 shows the stability imparted by the water solubles of the sole, E.I.goat, E.I. sheep and chrome retanned leathers to skin debris from the sole of the foot.

To conclude, the water solubles from leathers viz. E.I. goat E.I. sheep, sole and chrome retanned leathers can stabilise the skin debris and can maintain the pH of the footwear nearer to the pH of the skin by their buffering action.

Table.1

Shrinkage temperature of R.T.T. tanned in water solubles

Type of water solubles	TS°C
From sole leather	76.5
From E.I. goat	74
From E.I. sheep	73
From chrome retanned leather.	62
Raw R.T.T	59

Table.2.

Shrinkage temperature of epidermal pieces from the goat tanned in water solubles.

Type of water solubles	TS°C
From sole leather	85
From E.I. leather	86
From retanned leather	73
Raw epidermis	71

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Summary and Conclusions:

Results of the present study can be summarised as following:

Leather can dispose of the perspiration produced by the foot in three different forms (a) by the property of water vapour permeability (b) by absorption as water vapour and (c) by absorbing as liquid sweat. Leather is compressible and resilient. It has a combination of elasticity and plasticity in proportion to make it flexible and at the same time prevent permanent deformation. The frictional properties of leather is such that it exerts a moderate grip between the foot and the walking surface to make the movement of the foot comfortable. Leather is light enough not to tire the foot in wear. These properties also vary depending on the type of leather and the type of tannage. Comparison of leather with some synthetic upper and linings show that synthetics have low water vapour permeability and generally higher stretch. Synthetics also have low percent set.

Determination of the foot temperature and relative humidity inside shoes shows that both temperature and relative humidity are important from the point of view of physiological comfort and that leather being porous and hygroscopic, can dispose off a great part of the perspiration produced by the foot to keep the temperature and relative humidity inside the shoes at a normal level. Making the shoe impermeable and non-absorbent increases the temperature and

relative humidity inside the [illegible] able in a short period of wear. [illegible] ment of temperature and relative humidity [illegible] shoes in hot as well as cold climatic conditions [illegible] index could be arrived at, from the values of which one could know whether the environmental conditions inside the shoe could be comfortable for the wearer.

A study of the buffering action by the water solubles of leathers indicate that vegetable tanned leathers can maintain the pH of leather nearer to pH of the skin thus contributing to the feeling of comfort. A study of fungi present in footwear showed that water solubles of leather are one of the main nutrients for them and that the presence of fungi can be a long range comfort problem in footwear which may be eliminated by use of fungicides or any other suitable methods.

Need for Additional Research:

The index for comfort arrived at in this investigation could be developed into a consumer index for comfort in shoes. This needs further work involving the index in relation to chosen properties of the shoe making materials so that it may become possible to predict if a given material, or materials in combination, would prove to be good for shoes.

List of Publications:

1 Physical properties of shoe upper materials and their effect on footwear comfort.

Muthiah, P.L., Ramanathan, N. & Nayudamma, Y. The Journal of the Indian Leather Technologists Association, 16, 78 (1968)

2 Fungal flora in footwear

Kamat, D.H. and Ramanathan, N. Biological Aspects of Leather Manufacture: 1969 Central Leather Research Institute, Madras-20

3 Studies on shoe climate contributing to Comfort

Nayudamma, Y., Kamat, D.H., Muthiah, P.L. and Ramanathan, N., (To be published in J. Soc. Leather Traders' Chemists)

Based on this work a thesis for the degree of Ph.D. was submitted to the University of Madras by D.H. Kamat.