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CORE YIELD AS A THEORETICAL ESTIMATE OF BALE YIELD IN A CHANGING REGAIN SITUATION

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ABSTRACT

From a theoretical study of the assumed moisture gradients in a bale of greasy wool, resulting from changes in ambient conditions, estimates of the bias in yield given by core samples have been made. The average core yield for a bale, having a 50 per cent wool base, which is moved from a 40 per cent RH environment to a 75 per cent RH environment, will theoretically be an over estimate by about 0,4 per cent after 4 weeks and by about 0,05 per cent after 12 weeks.

The average change in mass of 316 bales stored in Durban, East London and Port Elizabeth for periods between 3 weeks and 18 weeks, was a gain of 0,8 per cent which would correspond to a theoretical over estimate of yield by cores of 0,1 per cent.

The results of the analysis are in substantial agreement with those of David (CSIRO) who based his calculations on the Tanner model.

INTRODUCTION

One of the factors determining the value of a bale of greasy wool is the amount of clean dry wool present. The moisture content of wool fibres and hence the yield can vary significantly from one environment to another depending on the prevailing relative humidity. An equilibrium regain for clean wool of 9 *per cent* for a particular bale, corresponding to a RH of about 40 *per cent,* can change to 17 *per cent* when stored under higher humidity conditions of about 75 *per cent* RH. For a 150 kg bale having a 50 *per cent* wool base this could represent a 6 kg mass gain and the measured wool base would then be reduced to about 48 *per cent.* Clearly, due allowance for possible changes in the moisture content of weighed bales must be and is made.

Similar allowance is made when bales are core sampled and their yield objectively measured. However, one aspect of these varying regains that could be of importance is the non-uniform distribution of moisture in a bale when it is in a non-equilibrium state. In a rising regain situation the outer regions of a bale will contain more moisture than the inner regions until a new equilibrium is reached throughout the bale. This process can take many months. It is probably fair to say that all bales of greasy wool at all times have a non-uniform moisture content.

The degree of inhomogeneity may have serious practical consequences or it may be adequately allowed for by current handling and sampling techniques. David[1] of CSIRO has made calculations on the possible bias given by core samples from data obtained by Roberts and Smith on moisture absorption by a bale of scoured wool. He used the Tanner model to describe the moisture distribution for initial and final regains of about 10 *per cent* and 15 *per cent* respectively. He showed that the core yield could give a bias in certain circumstances of up to 0,2 *per cent,* and recommended that where severe moisture gradients exists the bales should be dried to uniformity before coring.

This report deals with a theoretical assessment of the accuracy of the bale yield from core samples. It is based on the work of Henry[2, 3] who considered the rate of absorption of substances by bulk materials in general, where the process could be exo- or endothermic and the moisture diffusion and heat dispersion processes could be relatively slow. He considered that the Laplace equation could describe the processes and showed that for a bale of wool say changing to a higher regain because of environment changes, the rate of change of moisture content in reaching a new equilibrium could reflect two stages. The first or fast wave would be associated with the heat exotherm while the second and much slower wave would be associated with the very slow dispersion of heat from the highly insulating mass.

The work of Cassie, King and Baxter[4] confirmed the essential correctness of Henry's analysis and demonstrated the presence of the two waves.

Later work in New Zealand and Australia by several authors studied regain changes in greasy wool bales and in scoured wool bales. I. K. Walker and co-authors[5–15] of the WRONZ in part 8 of his series of publications gave values for Henry's coefficients for wool. P. Nordon and others of the CSIRO Australia have published similar work[16–23]. In conjunction with A. R. Edmunds[16, 18] of WRONZ and A. G. Shanahan[19, 20] of CSIRO they have shown the presence of regain gradients in greasy bales (including wet bales) as received into the warehouse by using a Bale Humidity Probe.

PRACTICAL CONSIDERATIONS

Sheared wool is baled on the farm in the sheds and is transported to the wool stores at a port. Typical relative humidities and temperatures of the shed and the wool stores have been obtained from the meteorological data recorded at many places in South Africa. To illustrate the possible changes in regain the following table lists average temperatures and humidities for several regions at certain times of the year. Precision is not required here, only a general indication of the various levels.

Thus changes in equilibrium regain (clean wool) on storage could be up to about eight *per cent.* In this table the slight effect of temperature on regain has been ignored, its effect here will be to tend to reduce the difference in regain. Further, the wool need not and often is not at equilibrium with the ambient conditions, e.g. the wool may be slightly damp with early morning dew or it might be dry from being in the sun.

The effect of these changes in regain on yield can be found as follows. Let Y_0 be the initial yield before the regain changes, Y_1 be the yield under the new humi-

District	RH	°C	Approximate Equilibrium Regain
Bloemfontein	40	16	12
Prieska	45	16	12,6
Beaufort West	50	14	13,2
Somerset East	55	18	13,8
Somerset East	60	18	14,5
Port Elizabeth	75	18	19

dity conditions at equilibrium and R the change in equilibrium regains, from before to after, then the approximate change in yield is given by

$$Y_O - Y_1 = \frac{R \times Y_O}{100} \times \frac{Y_1}{100} = \frac{R \times Y_O^2}{10\,000} \quad \text{(approximately)}$$

Thus the effect of an eight *per cent* increase in regain would be:—

Initial Yield	Change in Yield %	New Yield %
40	1,28	38,7
50	2,0	48,0
60	2,88	57,1
70	3,92	66,1

Control of the yield determination starts with the weighing of the bale as it enters the wool stores. No allowance is made for any change occurring before this, except for obviously "wet" bales. The bale mass at the time of coring and at dispatch are measured and corrected yields determined.

THEORETICAL CONSIDERATIONS

The behaviour of wool fibres when moved to an atmosphere of higher humidity can be explained in a simplified manner as follows. Initially the fibre is in equilibrium with a low humidity atmosphere, and its moisture content and temperature are constant. On raising the external humidity, the fibre very quickly (within seconds for a freely exposed fibre[5]) absorbs extra moisture, its temperature is raised by the evolution of the heat of absorption and moisture equilibrium is attained. The temperature, however, is not at equilibrium, so heat has to be dissipated. The temperature falls slowly and the moisture equilibrium is upset, so that more moisture has to be absorbed. This process continues until both moisture and temperature are in equilibrium with the atmosphere. The rate of attainment of equilibrium is controlled by the rate of dissipation of heat from the mass of fibres which is a much slower process than the rate of absorption of moisture.

This behaviour can be described mathematically by the Laplace equation

$$\frac{dR}{dt} \alpha \frac{d^2 R}{dx^2}$$

or the rate of change of regain with time, at any point in a bulk sample (a bale in the case considered here), is proportional to the rate of change of the regain gradient with respect to its position in the sample or bale.

Henry[2] gave (see Table II) the fractional change (of regain), f, at any time, Θ, after the move from one environment to another and at any point, ξ, within the thickness of a plane or slab, of infinite area, of substance (wool fibres).

His time factor Θ is given by

$$\Theta = \frac{Dt}{4a^2}$$

where D is a property of the bulk fibre
t is time in seconds
a is the half thickness of the slab in cm.

The position factor is given by

$$\xi = \frac{x}{a}$$

Where x is the distance of the point under consideration from the centre plane of the slab. ξ has a value of one at the surface and zero at the centre.

Walker and Harrison have published data which suggests that at a bulk density of 0,2 g/mℓ greasy wool at 21°C has a D value of 4 x 10^{-5} cm^2/sec. This will give, when 'a' equals 40 cm, a real time of 18,5 days for Θ equal to 0,01.

The conversion of Θ-values used in tables VI, VII and VIII are shown in Table I.

TABLE I

CONVERSION OF UNITS INTO REAL TIME

Θ	't' (days)
0,003	5,6
0,006	11,1
0,01	18,5
0,02	37
0,04	74
0,10	185

TABLE II

FRACTION OF CHANGE (x 10^{-3}) RECEIVED AT A POINT ξ DISTANCE FROM THE CENTRE OF A PLANE, AFTER A TIME Θ, FOR DIMENSIONS $x = y = 2/3 \, . \, z$

Fractional distance, ξ, from centre	TIME FACTOR Θ FOR x AND y						EQUIVALENT TIME FACTOR FOR z					
	0,003	0,006	0,010	0,020	0,040	0,100	(0,003) 0,0013	(0,006) 0,0026	(0,010) 0,0044	(0,020) 0,0089	(0,040) 0,0176	(0,100) 0,0444
0	0	0	0,8	24,6	154,2	525,6	0	0	0	0,4	17,1	186,0
0,2	0	0,3	4,7	48,2	191,2	548,8	0	0	0	2,9	36,2	222,3
0,4	0,1	6,2	33,9	134,0	302,1	616,0	0	0	1,9	24,8	111,4	330,4
0,6	9,9	67,9	157,3	317,7	484,2	720,9	0,1	7,0	34,7	133,1	286,3	506,3
0,7	53,0	170,7	288,8	453,3	598,5	784,3	4,3	41,2	110,6	259,2	423,6	616,2
0,8	196,5	361,4	479,5	617,0	725,1	853,2	53,5	168,9	285,2	451,6	596,1	737,4
0,85	330	493,7	595,9	707,6	991,7	889,0	144,9	300,5	422,2	572,1	688,7	801,2
0,9	518,7	648,1	723,7	802,6	860,2	925,7	328,6	485,8	592,0	706,3	789,3	866,5
0,95	746,9	819,6	859,6	900,5	929,9	963,8	624,2	728,7	788,7	850,5	893,6	933,0
Overall	123,5	174,7	225,6	319,0	451,2	697,9	82,0	115,9	149,8	212,3	300,0	473,4

For example, in Table II consider part of the row corresponding to Θ = 0,0006, which is equivalent to about eleven days if a value of 4×10^{-5} is taken for D and 'a' is 40 cm (half the width of a normal bale). There will be no change in regain at the centre (ξ = o and f = o). At 16 cm from the centre, 0,0062 of the eventual change will have taken place (ξ = 0,4, f = 0,0062).

If initial and final regains of 10 *per cent* and 18 *per cent* are considered, the regain at this point will be

$$10 + (18 - 10) \times 0{,}0062 = 10{,}0496.$$

Similarly at Θ = 0,95 or 2 cm from the surface the fraction received will be 0,8196 which would correspond to a regain of 16,5568.

The final row indicates the average or the overall value for f which in this case is 0,1747 or a regain of 11,3976.

In the above calculations the changing regain by moisture penetration from one direction only has been considered. In practice all directions are involved, the length, breadth and height. In a given time, the fractional regain will be higher because moisture is arriving from three directions. The combination of these separate sources is effected by

$$f_t = 1 - (1 - f_x)\ (1 - f_y)\ (1 - f_z)$$

where f_t = fractional total effect

f_x, f_y, f_z = fractional regains from the x, y and z directions.

If the bale is a cube then at any point in the bale or in time

$$f_x = f_y = f_z$$

and

$$f = 3f_x + 3f_x^2, + f_x^3$$

i.e. the combined effect is greater than the sum of the three effects taken singly, as can be expected.

CALCULATIONS

Bales of wool generally have a square section ($x = y$) and a larger height ($z > x$). Half dimensions of $40 \times 40 \times 60$ cm^3 for the x, y and z directions, are typical. Because the value of 'a' in the 'x' direction is only two thirds of its value in the 'z' direction and as real time 't' is proportional to Θ times 'a' squared then the Θ values to be used for the 'z' direction must be only four-ninths of those used for the 'x' direction. Thus, if a time factor for Θ is taken as 0,006, for 'x' and 'y' directions, the corresponding Θ value for the 'z' direction will be 0,00266 and the corresponding values of f_z can be interpolated from the full table given by Henry.

Because of symmetry, only one eighth of a bale needs to be considered. Nine time factors (Θ) were considered ranging from 0,003 to 0,80, the approximate time scale being from a few days to several years.

Table II gives the f_x (and f_y) values at nine positions in the x (and y) direction. In the other half of the table the corresponding Θ values for $z = 1{,}5x$ and the

f_z values are given for each of nine positions in the z-direction. Also given are rows for overall values for f_x, f_z and f bale.

The f_t values was calculated for each of the 9 x 9 x 9 positions within this one-eighth of a bale, at each of nine different times. Again, due to symmetry only one sixteenth of the bale needs be considered, namely the wedge shaped piece sectioned by a vertical diagonal plane. Table III gives a typical set of total fraction received from the three directions at any point for $\Theta = 0{,}006$, for 'x' positioned at 0,6 and for several 'y' and 'z' positions.

By considering the effect of increased moisture absorption to change the equilibrium yield from say 50 *per cent* to 48 *per cent*, the centre point of this section through the bale ($f_t = 0{,}068$) will yield 50 *per cent* less 2 x 0,068 *per cent* or 49,874 *per cent* while the outer layer ($f_t = 1{,}00$) will yield 48 *per cent*.

TABLE III

FRACTION (x 10^3) OF THE POSSIBLE CHANGE RECEIVED AT POINTS IN THE VERTICAL PLANE THROUGH $x = 0{,}06$ FOR $\Theta = 0{,}006$

y \ z	0	0,2	0,4	0,6	0,7	0,8	0,85	0,9	0,95	1,0
0	68	68	68	74	106	225	348	521	747	1 000
0,2	68	68	68	75	106	226	348	521	747	1 000
0,4	74	74	74	80	112	230	352	524	749	1 000
0,6	131	131	131	137	167	278	392	553	764	1 000
0,7	227	227	227	232	259	358	459	603	790	1 000
0,8	405	405	405	409	429	505	584	694	839	1 000
0,85	528	528	528	531	548	608	670	757	871	1 000
0,9	672	672	672	674	685	727	771	831	911	1 000
0,95	832	832	832	833	839	860	882	914	954	1 000
1,0	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000

The average value for the z-columns in Table III, which can be regarded as complete cores for each of these nine positions of y, is given in Table IV.

Thus a core at a position through the horizontal diagonal at a fractional distance of 0,6 from the centre would have gained only 0,232 fraction of the ultimate change. Its yield would be, say, 50 – 2 x 0,231 *per cent* or 49,538 *per cent*. The average fraction for the full bale at this time would be 0,398 giving a yield of 49,204 *per cent*. Thus this full core would over-estimate the bale yield by

TABLE IV

FRACTION RECEIVED BY A FULL CORE AT EACH '*y*' POSITION FOR $x = 0{,}6$ AND $\Theta = 0{,}006$

y	0	0,2	0,4	0,6	0,7	0,8	0,85	0,9	0,95	1,0
Fraction received by core	0,176	0,176	0,181	0,232	0,317	0,474	0,583	0,710	0,851	1,000

0,334 *per cent.* In practice the Model T ejects the top 5 *per cent* of the core and it has been found that it does not cut the bottom regions which could be up to 15 *per cent.* Recalculation of the values given in Table IV using only '*z*' values up to 0,95 and again up to 0,85, and taking the average, gives the fractions received by these partial-cores at those positions corresponding to Table IV. Table V illustrates.

TABLE V

PART-CORE FRACTIONS

y	0	0,2	0,4	0,6	0,7	0,8	0,85	0,9	0,95	1,0
core fraction =	0,127	0,127	0,132	0,183	0,267	0,424	0,533	0,660	0,802	1,000

The part core at the 0,6 position, as above, would therefore yield 49,634 *per cent* which differs from the bale by 0,430 *per cent* yield.

These calculations of the fractions received by full cores and part cores (as defined above) for each of 7 times 7 '*x*' and '*y*' positions and at each of six different time (Θ) values are given in Tables VI and VII.

IWTO coring regulations prohibit the taking of cores from the outer 10 cms.

TABLE VI

FRACTION (x 10³) OF CHANGE IN A FULL CORE AT EACH OF 49 POSITIONS FOR *x* AND *y*, FOR DIFFERENT TIME PERIODS Θ

y	0	0,2	0,4	0,6	0,7	0,8	0,9	0	0,2	0,4	0,6	0,7	0,8	0,9
Θ = 0,003								Θ = 0,02						
x = 0	84	84	84	93	133	264	559	255	273	338	479	582	707	849
0,2	84	84	84	93	133	264	559	273	290	354	491	592	714	853
0,4	84	84	85	94	133	264	559	338	354	413	537	629	740	866
0,6	93	93	94	102	141	271	564	479	491	537	635	708	795	895
0,7	133	133	133	141	179	303	583	582	592	629	708	766	836	915
0,8	264	264	264	272	303	409	646	707	714	740	795	836	885	941
0,9	559	559	559	564	583	646	788	849	853	866	895	915	941	969
Θ = 0,06								Θ = 0,04						
x = 0	119	119	124	178	269	437	690	503	524	590	697	764	838	918
0,2	119	119	124	179	269	437	690	524	545	608	710	774	845	921
0,4	124	124	129	184	274	441	692	590	608	661	750	805	867	932
0,6	178	179	184	234	319	475	711	697	710	750	815	856	901	950
0,7	269	269	274	319	394	533	743	764	774	805	856	888	923	961
0,8	437	437	441	475	533	641	802	838	845	867	901	923	947	973
0,9	690	690	692	711	743	802	891	918	921	932	950	961	973	986
Θ = 0,01								Θ = 0,01						
x = 0	155	158	183	287	398	560	766	882	888	905	931	946	964	982
0,2	158	161	186	290	401	561	767	888	894	909	934	949	965	982
0,4	183	186	210	311	418	574	774	905	909	923	944	957	971	985
0,6	287	290	311	399	492	629	803	931	934	944	959	969	979	989
0,7	398	401	418	492	572	687	834	946	949	957	969	976	983	992
0,8	560	561	574	629	687	771	878	964	965	971	979	983	989	994
0,9	766	767	774	803	834	878	935	982	982	985	989	992	994	997

For Θ = greater than 0,1 the tabled values exceed 0,989

This means that cores must not be taken from those regions whose *x* and *y* co-ordinates are greater than 0,75. If cores are taken at random within this limited region of *x* and *y*, the average core will be represented by the fractional volume under the three dimensional curve for f_t versus *x* and *y* up to fractional distances from the centre of 0,75.

TABLE VII

FRACTION (x 10^3) OF CHANGE RECEIVED BY PART-CORES AT EACH OF 49 POSITIONS FOR *x* AND *y* FOR DIFFERENT TIME PERIODS Θ

y	0	0,2	0,4	0,6	0,7	0,8	0,9	0	0,2	0,4	0,6	0,7	0,8	0,9
Θ = 0,003								Θ = 0,02						
y = 0	28	28	28	38	81	219	532	190	210	281	434	546	682	836
0,2	28	28	28	38	81	219	532	210	229	299	447	557	690	840
0,4	28	28	28	38	81	219	532	281	299	362	497	597	718	855
0,6	38	38	38	47	88	227	537	434	447	497	604	683	778	885
0,7	81	81	81	88	128	260	557	546	557	597	683	746	822	908
0,8	219	219	219	227	260	374	624	682	690	718	778	822	875	936
0,9	532	532	532	537	557	624	775	836	840	855	885	908	936	967
Θ = 0,006								Θ = 0,04						
x = 0	55	55	61	119	216	396	667	455	479	551	668	741	823	910
0,2	55	55	61	119	216	396	667	479	502	570	682	753	831	914
0,4	61	61	66	124	221	400	669	551	570	629	726	787	854	926
0,6	119	119	124	179	269	437	690	668	682	726	797	842	892	945
0,7	216	216	221	269	350	499	724	741	753	787	842	877	916	957
0,8	396	396	400	437	499	615	788	823	831	854	892	916	942	971
0,9	667	667	669	690	724	788	882	910	914	926	945	957	971	985
Θ = 0,10								Θ = 0,10						
x = 0	87	91	118	231	351	525	747	870	883	895	924	941	960	980
0,2	91	95	122	234	353	527	748	883	883	901	928	944	962	981
0,4	118	122	147	251	372	541	756	895	901	915	938	952	968	984
0,6	231	234	251	351	453	599	787	924	928	938	955	965	976	988
0,7	351	353	372	453	538	662	820	941	944	952	965	973	982	991
0,8	525	527	541	599	662	753	868	960	962	968	976	982	988	993
0,9	747	748	756	787	820	868	930	980	981	984	988	991	993	997

For Θ greater than 0,1 the table values exceed 0,988

In Table VIII this average part core fractional value has been calculated as has the full core fraction and the bale average for each of nine time periods.

TABLE VIII

Θ	Days	Fractional Change for average		Bale average fraction	Difference between bale and	
		full core	part core		part core	full core
0,003	5,6	0,105	0,050	0,294	0,244	0,189
0,006	11,1	0,190	0,131	0,398	0,267	0,208
0,01	18,5	0,289	0,232	0,490	0,258	0,201
0,02	37	0,472	0,425	0,635	0,210	0,163
0,04	74	0,689	0,660	0,789	0,129	0,100
0,1	185	0,929	0,922	0,952	0,030	0,023
0,2	370	0,994	0,993	0,996	0,003	0,002
0,4	740	1,000	1,000	1,000	0,000	0
0,8	1480	1,000	1,000	1,000	0,000	0

Figure 1 illustrates this Table.

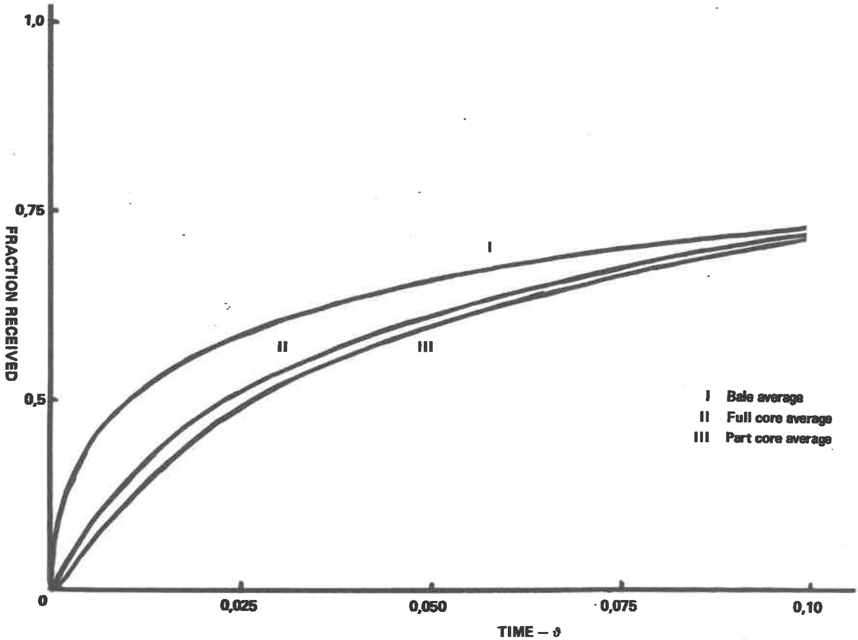

FIGURE 1

Average Fraction of regain change attained by bale and by core

The differences between the fractional change of the bale as a whole and the average part core during the first few weeks that a bale is stored in a different environment, i.e. one which has a significantly different temperature and relative humidity, are about 0,25. The full core gives a difference of 0,20. If the equilibrium regains (clean wool) for the two environments differ by about 8 *per cent* and if the wool base is 50 *per cent* from the first environment then the average core will give a higher yield, by about 0,5 *per cent,* than the bale average. This particular bale would have a mass increase of about 4%.

After any given time of storage there will be a region in the bale, represented by a core, whose regain is equal to the average for the bale. For Θ = 0,003 this region is approximately 0,8 of the distance from the centre. Table IX gives this information for other time periods.

TABLE IX

APPROXIMATE DISTANCE OF CORE FROM BALE CENTRE FOR CORE YIELD TO EQUAL BALE YIELD

Storage time period	Distance of core from centre	Equivalent to distance from side of
0,003	0,82	7,2 cm
0,006	0,80	8,0 cm
0,010	0,77	9,2 cm
0,020	0,76	9,6 cm
0,040	0,76	9,6 cm
0,100	0,75	10,0 cm

If a bale was perfectly homogeneous (excluding regain considerations) then the ideal coring position would be within the prohibited region when the bale is in the early part of its storage life. Later the required position moves to the boundary of the permitted region and stays there. Ultimately of course, at equilibrium, any core position will fulfil the requirements.

Measured change in mass of greasy bales:

To gain some idea of the size of the possible mass changes, data from bales stored in Durban, East London and Port Elizabeth wool stores were examined. They showed that for 120 bales at Durban, stored for between 3 weeks and 10 weeks an average loss of 0,3 *per cent* in mass occurred. At East London, 120 bales stored for periods of between 3 weeks and 12 weeks had an average gain in mass of 0,2 *per cent* while 76 bales stored at Port Elizabeth for periods between 7 weeks and 18 weeks had an average gain in mass of 2,6 *per cent.*

The mass changes at Durban and East London were small, on average. The large change at Port Elizabeth could be expected, on the basis of the above analysis, to result in core tests giving a significantly biased or over estimate of the yield, if the coring were done at the time of the second weighing.

If the mass change when equilibrium was attained would have been four *per cent,* then the observed 2,6 *per cent* represents two-thirds of this change. From the values given in Table VIII this would correspond to about seven weeks storage which is in fair agreement with the known storage. The core bias at this time is 0,2 and so a 50 *per cent* yield would have been overestimated by about 0,4 *per cent.* Only by coring at the time of reception would the bias be avoided.

There still remains the possibility that the bale changes its mass during its transit from the packing station to the port wool store. If this were significant then ideally coring would have to be done at the packing station to avoid bias. One further factor follows from these considerations, the uniformity of the moisture content of individual fleeces before they are packed into a bale should be considered.

The theoretical analysis has indicated that cores could possibly give biased yield values. A few practical measurements have confirmed that in some circumstances this bias can exist. To minimise this possiblity it is recommended that bales are cored virtually at the time of receipt into the wool store. For post-sale testing it is recommended that note be taken of bale mass changes and that for every one *per cent* increase in mass (due to moisture) a bias of 0,1 *per cent* in yield be considered when the storage period is about one month and a bias of 0,05 *per cent* for a three months storage period. As, however, post-sale coring is often done with hand corers, the changing moisture pattern of stacked bales may differ somewhat from the above.

SUMMARY

The equilibrium regain of bales of wool under the humidity conditions of the shearing and packing sheds is often lower, in South Africa, than that at the port warehouses. Differences in bale mass of up to 4 *per cent* are possible when average humidities are considered.

It is well-known that the attainment of equilibrium by greasy bales, after moving to a new environment, is a lengthy process. The regain of cores taken from such a bale are possibly different from the average for the bale, at the time of coring and hence could give a different yield. By applying Henry's and Casie's treatment to a standard sized bale the regain at many points within the bale has been in effect calculated. By integrating the vertical columns over the cross-section and omitting those portions, which are not taken by the cores, typical average core regains (clean wool) were calculated. Because IWTO regulations do not permit cores to be taken from near the sides of a bale, i.e. within 25 *per cent* of the sides, the average core regain, with this limitation, has been calculated and compared with the

full bale average regain. These regains have been expressed as fractions of the ultimate new equilibrium regain. The difference in this fraction between the average core and the bale average varies with time of storage from zero to a maximum of about 0,2. This corresponds to a difference in yield of about 0,4 *per cent,* assuming an eight *per cent* change in equilibrium regain (clean wool) and a wool base of 50 *per cent.* In other words, model T cores could, in theory, over estimate the yield by up to 0,5 *per cent.*

To minimise the possibility of bias it is recommended that bales are cored as soon as they are received into the wool store. For post-sale testing it is recommended that a bias of 0,1 *per cent* be considered for a one *per cent* mass increase over a one month storage period. Hand-cored stacked bales may behave somewhat differently.

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