Hay

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MEASURING HAY IN RICKS OR STACKS

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MEASURING HAY IN RICKS OR STACKS.

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The methods presented here for determining the number of tons of hay in a rick or stack are in no way official. They simply represent the results of a somewhat extended investigation of the subject covering a period of several years. It is believed, however, that the method suggested for determining the number of cubic feet in a rick or stack of hay is quite accurate. The formulas given should be considered merely as the nearest approach we are able to make with our present knowledge.

THE PROBLEM OF MEASURING HAYRICKS

The problem of obtaining an accurate formula for determining the number of cubic feet in a hayrick is difficult because of the variation in the shape of ricks. Even if the number of cubic feet in a rick is known, the problem of converting this into tons is difficult because of the wide variation in the compactness of hay in bulk.

For the purposes of this study the actual number of cubic feet in a ton of hay in ricks has been determined by measurement in 92 cases. The results are very variable and show that any general rule for determining the weight of hay in a rick by measurement must be only an approximation. But thousands of tons of hay are sold annually on such measurements, and therefore it is desirable to establish at least average values for the quantities concerned in these measurements.

MEASURING THE VOLUME OF A HAYRICK

The volume of a rick is equal to its length multiplied by the area of its cross section. The length is easily measured. Let us consider the principles involved in measuring the area of the cross section. If the top of the rick were perfectly flat and the two sides straight up and down, the area of the cross section would simply be the width multiplied by the height. If the rick were triangular in cross section, so that the sides represented straight lines from the top of the rick to the bottom on each side

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the area of the cross section would be one-half of the product of the base and the height. The actual area of the cross section lies somewhere between these two.

It is difficult to measure accurately the height of a rick. It is much easier to measure the "over," which is the distance from the ground on one side of the rick over the top of the rick to the ground on the other side. The length of the over depends upon three things: (1) Width, (2) height, and (3) "fullness" of the rick. The over is always somewhat more than twice the height.

It has been found by actual measurement that the cross section of a rick is the product of the over and the width, multiplied by a fraction varying from 0.25 to 0.37 (average value, 0.31), depending upon the height and fullness of the rick. If the rick is low in comparison with its width and nearly triangular in outline—that is, its sides are not very full—the fraction is small (0.25). If the rick is tall in comparison with its width, and the sides are very full, so that the top is well rounded, the fraction is large (0.37). Representing this fraction by F, the over by O, the width by W, and length of the rick by L, the volume being resented by V, we have the following formula for determining the number of cubic feet in a rick:

$$Volume = Fraction \times Over \times Width \times Length$$

or, as commonly written,

$$V = FOWL$$

The fact that the right-hand member of this formula spells the word, "fowl" makes it easy to remember.

Figure 1 shows the cross sections of hayricks of nine different shapes, the corresponding value of the fraction F for each of these shapes being inserted in the outline of each cross section. The height of ricks Nos. 1, 4, and 7 (upper row) is three-fourths the width. The height of ricks Nos. 2, 5, and 8 (middle row) is equal to the width, while the height of ricks Nos. 3, 6, and 9 (lower row) is one and one-fourth times the width. Ricks Nos. 1, 2, and 3 (left column) are narrow or nearly triangular in outline; ricks Nos. 4, 5, and 6 (middle column) are medium full, while ricks Nos. 7, 8, and 9 (right column) are full and rounded. It will be noticed that the value of F is the same (0.31) in Nos. 3, 5, and 7; in Nos. 2 and 4 it is 0.28; and in Nos. 6 and 8, 0.34.

In attempting to find the volume of hayricks the choice between these various values of F may be found by comparing the shape of the end of the rick—that is, the cross section of the rick

—with ricks Nos. 1 to 9 in figure 1. If the shape of the rick to be measured is intermediate between those shown in figure 1, intermediate values of F may be used. The use of the above formula may be made clear by a few examples:

Example 1.—A hayrick is 16 feet wide, 24 feet long, and the over is 31.2 feet. The end view indicates that the shape of the rick is very close to No. 4 in figure 1. What is the volume of the rick?

Solution: $V=0.28\times31.2\times16\times24=3{,}354.6$ cubic feet.

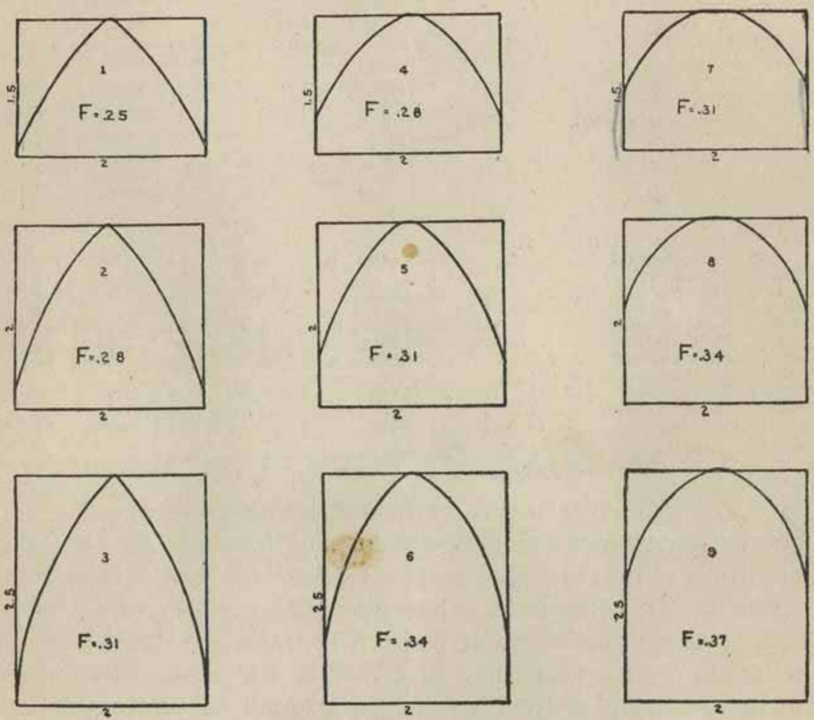

Fig. 1.—Cross sections of hayricks of different shapes.

Example 2.—A hayrick is 14 feet wide, 20 feet long, and the over is 34.2 feet. Inspection of the end of the rick shows that it is of the type of No. 8 in figure 1. What is the volume of the rick?

Solution: $V=0.34\times34.2\times14\times20=3{,}255.8$ cubic feet.

ERROR IN MEASURING

In general, hayricks are more often measured short than long, The reason for this is because allowance is made on account of the sides of the stack being not well settled or pressed in. It sometimes happens that the corners are not square, which also tends to lead one to measure the rick short.

Table I shows the loss occurring when nine stacks, representing the nine different shapes provided for in the rule, and having the same width and length, are measured 6 inches short in any dimension. If any care at all is exercised in measuring, the error should never amount to more than 6 inches, unless the stack is very irregular and unsymmetrical.

TABLE I.—*Number of cubic feet and per cent of loss when stacks are measured "short."*

Kind of stack.	Total cubic feet in stack.	Loss from measuring—over, length, or width 6 inches short.					
		Over.		Length.		Width.	
		Cubic feet	Per cent of total.	Cubic feet	Per cent of total.	Cubic feet.	Per cent of total.
Low stacks (l. 30′, w. 16′, o. 32′):							
No. 1. Narrow stack	3,840	60	1.55	64	1.66	120	3.12
No. 4 Medium full	4,300	67	1.55	71	1.66	134	3.12
No. 7. Full rounded	4,760	74	1.55	78	1.66	148	3.11
Medium tall stacks (l. 30′, w. 16′, o. 37′):							
No. 2. Narrow stack	4,972	67	1.35	83	1.66	155	3.11
No. 5. Medium full	5,505	74.5	1.35	92	1.66	172	3.12
No. 8. Full rounded	6,038	81	1.35	101	1.66	189	3.13
Tall stacks (l. 30′, w. 16′, o. 48′):							
No. 3. Narrow stack	7,142	74.5	1.04	119	1.66	233	3.12
No. 6. Medium rounded	7,833	81.5	1.04	130	1.66	245	3.13
No. 9 Full rounded	8,524	88.5	1.04	158	1.66	266	3.12

ERROR IN MEASURING OVER

An error of 6 inches short in measuring over causes a loss of 1.55 per cent for the three low shapes of stacks. The per cent of loss for medium-tall stacks is 1.35, and for tall stacks is 1.04 per cent. This loss is less than when the same error in measuring is made in the length or width. There is less danger of measuring the over wrong than of either of the other two measurements, because the tape is from the ground or bottom of stack on one side to the ground or bottom of the stack on the opposite side, and there is no necessity for guessing unless the top is uneven, in which case the average of two or three measurements taken at different points should be used.

In measuring stacks having the same width and over, but of varying length, the amount of hay lost varies, but the per cent of total hay remains constant.

ERROR IN MEASURING LENGTH

An error of 6 inches short in measuring for length will cause a loss of 1.66 per cent in each of the nine types. The loss in stack No. 1 is 64 cubic feet, and is increased gradually for each shape in the order given in Table I up to No. 9, in which the loss amounts to 158 cubic feet, or about one-third of a ton, when using 512 cubic feet to the ton.

The loss caused by measuring the length short is about the same as the loss caused by measuring the over short for the three shapes of low stacks, is about 20 per cent more for medium-tall stacks, and is about 70 per cent greater for tall stacks. The amount of hay lost in measuring a number of stacks having the same width and over, but varying length, is always the same, although the per cent of loss decreases as the length increases.

ERROR IN MEASURING WIDTH

Not only is it more difficult to make correct measurements of width than of other dimensions, but the same amount of error in measuring width as in measuring length and over causes a much greater loss of contents. As there is but little difficulty in measuring the over correctly, it is only necessary to compare the amount of loss from error in measuring width with length. An error of 6 inches short in measuring width causes a loss of about 3.12 per cent for each of the nine shapes in Table I. The loss for stack No. 1, which is a narrow, low stack, amounts to 120 cubic feet, and the loss gradually increases from this up to 266 cubic feet—over one-half ton—in stack No. 9. The loss in incorrectly measuring the width is roughly twice as great as that sustained by measuring the length incorrectly, and therefore in measuring stacks more care should be exercised in measuring width than in measuring length.

A method the writers found to be quite accurate in measuring width or length was to use two stakes, each stuck in the ground at the sides of the stack. By sighting along the side of the stack at a distance of 50 or 100 feet, the stakes can easily be placed at the exact point desired to indicate the dimensions.

COMPARISON FOR RULES FOR MEASURING HAY

Comparative tests of the various rules in use for measuring hay show a variation of volume amounting, in some instances, to over 50 per cent. Quite often serious disputes arise over the amount of hay found to be contained in a rick when certain rules are used. Often the matter is taken into court for settlement.

In the Table II the department rule is compared with two other rules quite commonly used. The first is known as the "Quartermaster's Rule," and is often wrongly called the "Government" rule. This rule is as follows: Add the over and width and divide by 4; multiply the result by itself and then by the length; the result will be the volume in cubic feet. The second, commonly called the "Frye" rule, used a great deal in the middle West and West, is as follows: Subtract the width from the over and divide by 2; multiply by the width and then by the length; the result will be the volume in cubic feet.

TABLE II.—*Comparison of different rules.*

[On basis of 100 per cent for department rule.]

Kind of stack.	Department rule FOWL = Volume in cubic feet.	Quartermaster's rule $\left(\frac{o+w}{4}\right)^2 L =$ vol. in cubic feet		Frye-Bruhm rule $\left(\frac{o-w}{2}\right) wL =$ vol. in cubic feet	
		Cubic feet.	Per cent of department rule	Cubic feet.	Per cent of department rule.
Low stacks (l. 30′, w. 16′, o. 32′):					
No. 1. Narrow stack	3,840	4,320	112	3,840	100
No. 4. Medium full	4,300	4,320	100	3,840	89
No. 7. Full rounded	4,760	4,320	90	3,840	80
Medium tall stacks (l. 30′, w. 16′, o. 37′):					
No. 2. Narrow stack	4,972	5,266	105	5,040	101
No. 5. Medium full	5,505	5,266	97	5,040	91
No. 8. Full rounded	6,038	5,266	87	5,040	83
Tall stacks (l. 30′, w. 16′, o. 48′):					
No. 3. Narrow stack	7,142	7,680	107	7,680	107
No. 6. Medium full	7,833	7,680	98	7,680	98
No. 9. Full rounded	8,524	7,680	90	7,680	90

A comparison of the quartermaster's rule with the department rule shows that it is only adapted to the medium-full type of stacks. It gives the correct volume for only one shape in this type, namely, the medium-full, low stack, and is 3 per cent too low for the medium-full, medium-tall stack, and 2 per cent too low for the medium-full, tall stack. When used to find the volume of the other six shapes it varies from 13 per cent too low to 12 per cent too high, making the total variation amount to 25 per cent.

The Frye-Bruhm rule is much the same as the quartermaster's rule, with the exception that it is better adapted to the full-rounded type of stacks. It gives the correct volume only for the low, full-rounded stack, and is 1 per cent too high for the full-rounded medium-tall stack and 7 per cent too high for the full-rounded tall stack. For the other six shapes it varies from 2 per cent to 17 per cent too low, making the total variation 24 per cent when compared to the department rule. The Frye-Bruhm and quartermaster's rules usually divide volume by 512 to get tons, which will again cause a further variation, depending on how long the hay has been in the stack.

Thus it is easily understood how the indiscriminate use of these and other similar rules for all shapes of stacks will, in most cases, give incorrect results.

MEASURING ROUND HAYSTACK

The measurement of the number of cubic feet in a round stack of hay is more difficult than it is for a rick. Simple formulas for this can be developed, however, by considering the round stack in two parts. The lower part is usually cylindrical, or in some cases drawn in at the bottom so as to present in outline the appearance of a large pan, narrower at the bottom than at the top. The upper part varies in outline from a cone at one extreme to half a sphere at the other. The upper row of outlines in figure 2 represents these two extreme forms of top and a form intermediate between them. The lower row of outlines in figure 2 represents the two common shapes of the bottom part of round stacks. It is necessary to calculate the volume of the top and bottom parts separately and then add them together.

Formulas for making these calculations are given on the outline drawings in figure 2. Thus, in drawing No. 1 the formula for finding the volume of a perfectly conical top is—

$$V=0.027\ HC^2$$

In these formulas H represents the height of that portion of the stack being measured (not the full height of the stack), while C represents the circumference of the bottom portion of the top—that is, the circumference at the bulge or shoulder of the stack—

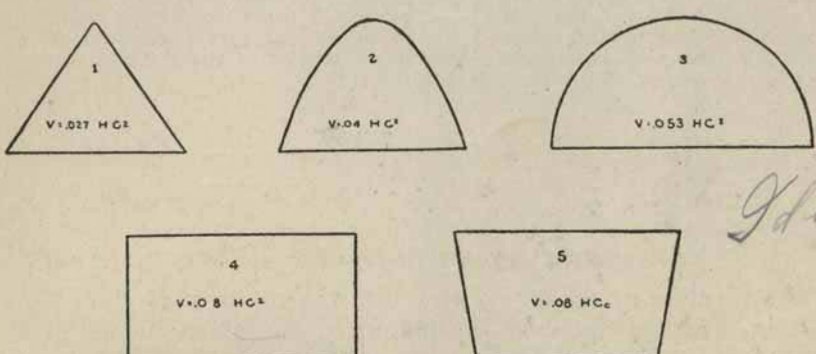

Fig. 2.—Diagram showing various shapes of round haystacks; 1, 2, and 3, upper part of stacks (above the bulge); 4 and 5, lower part of stacks (below the bulge). Formulas for calculating the volume are given in each figure.

and the small superior figure "2" to the right of C indicates that this circumference is to be squared; that is, multiplied by itself. The formulas for outlines Nos. 2, 3, and 4 need no further explanation. The use of these formulas will be indicated below.

The formula for drawing No. 5 in figure 2 ($V=0.08\ HCc$) means that the volume of the lower part (from the shoulder, or bulge, down) of a round stack shaped like the drawing is equal to 0.08 multiplied by the height of the base (H), this total multiplied by the circumference at the top of the base (C), and the product then multiplied by the circumference at the bottom of the stack (c).

In determining the volume of the tops of stacks it will be noticed that the decimal preceding the H in each of the formulas varies with the shape of the top. In order to use this formula in any given case, it will be necessary to determine by inspection what decimal to use. It will lie somewhere between 0.027 and 0.053. In measuring the volume of the base of the stack no such uncertainty exists, since the decimal in the formula is the same in all cases.

A few examples will illustrate the use of these formulas.

Example 1.—The base of a haystack is cylindrical and the top conical. The height of the base is 4 feet and the height of the top is 6 feet, the circumference of the stack at the ground and at the shoulder being 28 feet. What is the volume of the stack in cubic feet?

Solution:

Top of haystack...........	$V=0.027\times6\times28^2=127.0$ cubic feet
Bottom of haystack........	$V=0.08\ \times4\times28^2=250.9$ cubic feet
Total..................................	377.9 cubic feet

Example 2.—A haystack has a top similar in shape to outline No. 2 in figure 2 and the base of the shape of outline No. 5 in figure 2. The height of the top is 5 feet, the circumference at the bulge is 26 feet, the height of the base is 3½ feet, and the circumference at the bottom of the stack is 20 feet. What is the volume of the stack in cubic feet?

Solution:

Top of haystack.......	$V=0.04\times5\ \ \times26^2\ \ =135.2$ cubic feet
Bottom of haystack....	$V=0.08\times3\tfrac{1}{2}\times26\times20=145.6$ cubic feet
Total...................................	280.8 cubic feet

MEASURING THE HEIGHT OF HAYSTACKS

The formula given for determining the number of cubic feet in a stack of hay involves the height of the stack, which it is necessary to measure in some manner. It is also desirable sometimes to measure the height of a rick. Figure 3 shows a simple method of accomplishing this. In using this method two points

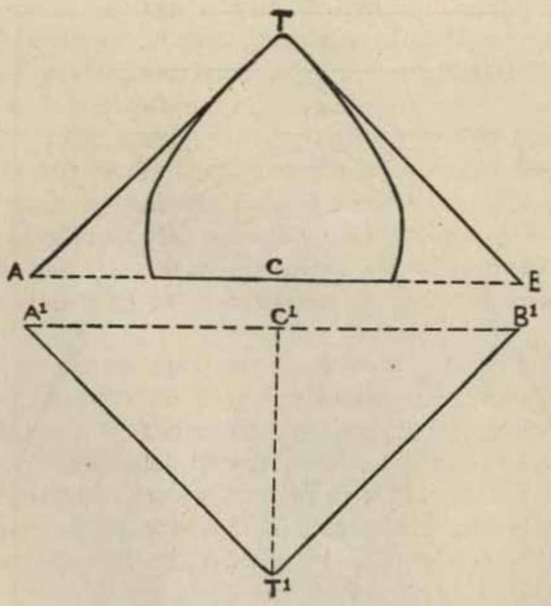

Fig. 3.– Diagram showing a method of measuring the height of stacks or ricks of hay.

are marked on the ground on opposite sides of the rick or stack and at as nearly equal distances from its center as possible. A cord is then thrown over the stack, stretched gently from the point *A* over the top of the stack to the point *B* and marked to show its length from *A* to *B*. The cord is then removed and placed on the ground in the position of *A′*, *B′*, and *T′*, the points *A′* and *B′* being exactly the same distance apart as *A* and *B*. At *T′* the cord should be made to assume the shape of that portion of the top of the stack with which the cord was in contact when it was stretched over the top of the stack. The distance C′ T′ will then be the height of the stack.

RATE OF SETTLING

Figure 4 shows the average rate of settling for stacks for 149 days. The average height is 14.6 feet when stacked for 3 days. This height is represented by 100 per cent at the third day. Thirty-five days later the average loss was 11 per cent. After 69 days in stack, the total loss in height amounted to 14 per cent, or 3 per cent more during 34 days. The total loss in height at the end of 146 days amounted to 17 per cent, or 3 per cent during the last 77 days, at which time the settling had practically ceased.

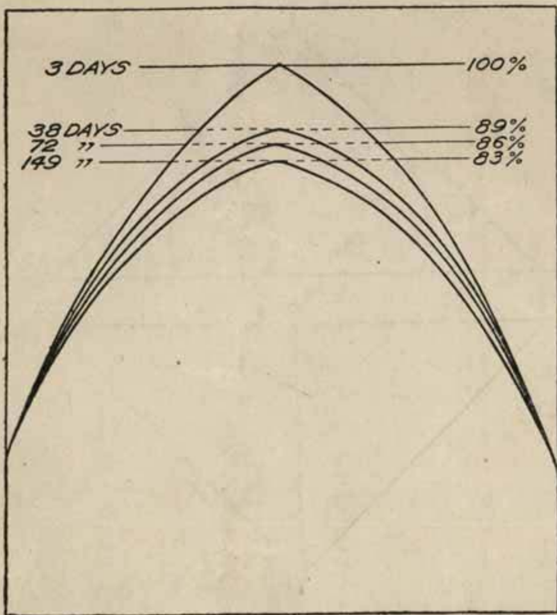

Fig. 4.—Diagram showing settling of hay and loss in volume when in stack 38, 72, and 149 days.

NUMBER OF CUBIC FEET IN A TON OF HAY

In connection with this study, 92 stacks were measured and the hay subsequently weighed with a view to determining the average number of cubic feet in a ton. The data were obtained in the states of Virginia and New York, stacks being mainly timothy or a mixture of clover and timothy in which timothy predominated. The measurements for volume were made immediately before baling, and the hay weighed as it was baled from the stacks. The results of these measurements are shown in Table III.

TABLE III.—*Cubic feet of hay in ton.*

[Averages from 92 stacks measured and weighed.]

Age of stacks in days.	Number of stacks measured and weighed.	Average cubic feet per ton.
Under 30	55	589.6
30 to 60	30	581.5
74 to 155	7	514.9

It will be noted that shrinkage makes a very marked difference in the number of cubic feet required to make a ton.

These figures apply only to clear timothy or a mixture timothy and clover. No definite measurements of other kinds of hay have been made.