AS-1282 (Revised)

WEIGHTS and MEASURES of Common Feed

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In calculating rations and mixing concentrates, using weights rather than measures usually is necessary. However, in practical feeding operations, measuring the concentrates often is more convenient for the farmer or rancher.

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FORAGE

Storage Space Requirements for Feed and Bedding

The space requirements for feed storage for the livestock enterprise – whether it is for cattle, sheep, hogs or horses, or as is more frequently the case, a combination of these – vary so widely that providing a suggested method of calculating space requirements applicable to such diverse conditions is difficult. The amount of feed to be stored depends primarily upon (1) length of pasture season, (2) method of feeding and management, (3) kind of feed, (4) climate, and (5) the proportion of feeds produced on the farm or ranch in comparison with those purchased.

Normally, the storage capacity should be sufficient to handle all feed grain and silage grown on the farm and to hold purchased supplies. Forage and bedding may or may not be stored under cover.

In those areas where weather conditions permit, hay and straw frequently are stacked in the fields or near the barns in loose, baled or chopped form. Sometimes sheds or a waterproof cover is used for protection. Other forms of storage include temporary upright silos, trench silos, temporary grain bins and open-wall buildings for hay.

Hay Weight in a Stack or Barn

Stockmen and hay dealers frequently buy and sell large quantities of hay in the stack or in the barn. This practice is prevalent especially in the Western and Great Plains states, where cattle and sheep are brought into the farm yard to be wintered on hay bought from hay producers.

Under such circumstances, the weight of hay usually is estimated because (1) no scales are available, and/or (2) weighing the hay is impractical due to the time, labor and wastage involved. In many such instances, the hay is fed directly from the stack or barn, in racks arranged about it. Under these and other circumstances, there is need for a simple and reasonably accurate method of estimating the weight of hay in a stack or barn.

To estimate the tonnage of hay in a stack or in a barn, you need to (1) compute the volume of hay, and (2) know the number of cubic feet per ton of hay. **Table 1** gives the density information.

Table 1. Storage space requirements for feed and bedding.

Kind of Feed or Bedding	Pounds per Cubic Foot	Cubic Feet per Ton	Pounds per Bushel of Grain
Hay			
1. Loose			
Alfalfa	4.0 -4.4	450-500	—
Nonlegume	3.3-4.4	450-600	—
Straw	2.0-3.0	670-1,000	—
2. Baled			
Alfalfa	6.0-10.0	200-330	—
Nonlegume	6.0-8.0	250-330	—
Straw	4.0-5.0	400-500	—
3. Chopped			
Alfalfa, 1½-inch cut	5.5-7.0	285-360	—
Nonlegume, 3-inch cut	5.0-6.7	300-400	—
Straw	5.7-8.0	250-350	—
Corn			
15½% moisture:			
Shelled	44.8	—	56.0
Ear	28	—	70.0
Shelled, ground	38	—	48.0
Ear, ground	36	—	45.0
30% moisture:			
Shelled	54	—	67.5
Ear, ground	35.8	—	89.6
Barley, 15% moisture	38.4	—	48.0
Ground	28	—	37.0
Flax, 11% moisture	44.8	—	56.0
Oats, 16% moisture	25.6	—	32.0
Ground	18	—	23.0
Rye, 16% moisture	44.8	—	56.0
Ground	38	—	48.0
Sorghum grain, 15% moisture	44.8	—	56.0
Soybeans, 14% moisture	46	—	60.0
Wheat, 14% moisture	48	—	60.0
Ground	43	—	50.0

Source: Adapted from Beef Housing and Equipment Handbook, Midwest Plan Service, Iowa State University, 4th edition, 1987, Table 8-13, pg. 8.21 and Table 8-17, pg. 8.22.

In using Table 1, you must recognize that many factors – other than kind of hay, form (loose, chopped, or baled) and period of settling – affect the density of hay in a stack or in a barn, including (1) moisture content at haying time, and (2) texture and foreign material.

Computing the volume of hay in a mow is relatively simple, but determining the volume of a stack is more difficult. Although different rules or formulas may be and are used, the U.S. Department of Agriculture[1] recommends the following:

1. **Volume of hay in barns**
   Multiply the width by the length by the height, all in feet, and divide by the cubic feet per ton as given in **Table 1**.

2. **Volume of hay in oblong and rectangular stacks**
   Three types of oblong stacks are common, as shown in **Figure 1** (page 3). The volume of each type of oblong stack may be determined as follows:

   a. For low, round-topped stacks:
   (0.52 x O) - (0.44 x W) x W x L

   b. For high, round-topped stacks:
   (0.52 x O) - (0.46 x W) x W x L

   c. For square, flat-topped stacks:
   (0.56 x O) - (0.55 x W) x W x L

   In these formulas, O is the "over" or "over-throw," which is the distance in feet from the ground on one side of the stack, up and over the stack and down to the ground on the other side; W is the width; and L is the length.

   The application of this formula is illustrated as follows:

   Example. *You want to estimate the amount of alfalfa hay in a low, round-topped type of oblong stack that has settled for four months. The stack is 20 feet wide, 30 feet long and has an over of 40 feet.*

   The answer is secured as follows:

   a. Volume = (0.52 x 40) - (0.44 x 20) x 20 x 30 = 7,200 cubic feet

   b. Table 3 shows that there are 470 cubic feet per ton of settled alfalfa

   c. 7,200 ÷ 470 = 15 tons of hay

3. **Volume of hay in round stacks**
   The rules or formulas used for oblong stacks do not apply to round stacks. But **Table 2** (pages 4-5) gives the volume of round stacks when the circumference is between 45 and 98 feet and the over between 25 and 50 feet.

   Calculate the volume of stacks having circumferences or overs greater or less than those given in Table 2 by using the following formula:

   Volume =
   $(0.04 \times O) - (0.012 \times C) \times C^2$

   In this formula, C equals the circumference or distance around the stack at the ground, and O equals the over or distance from the ground on one side over the peak to the ground on the other side (usually taking two measurements at right angles to each other and averaging them is best).

   Thus, the computation of the volume of a large, round stack may be illustrated by the following example:

   Example. *You want to determine the amount of alfalfa hay in a round stack that is 100 feet in circumference and has an average over of 60 feet.*

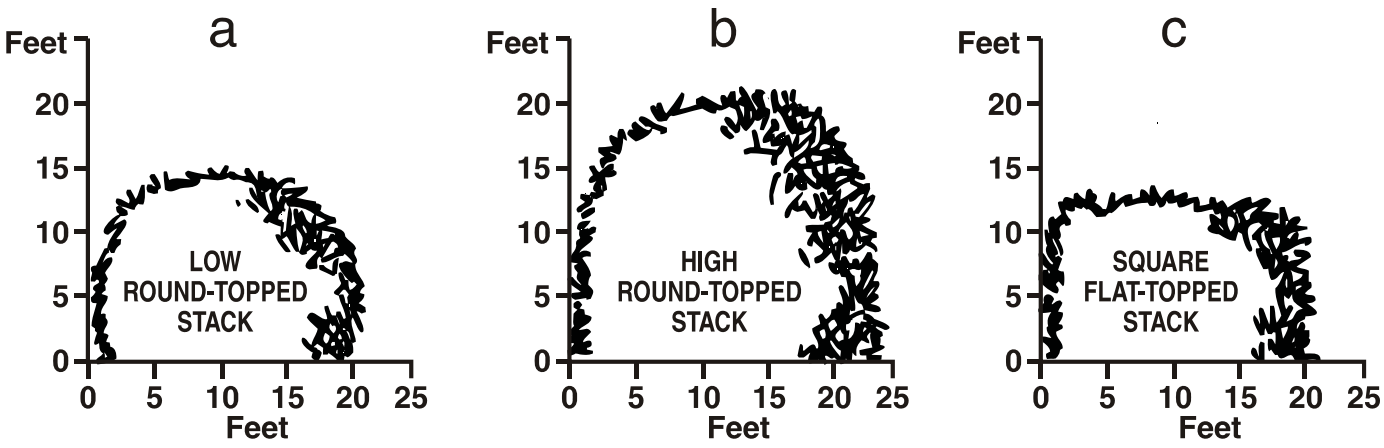


Figure 1. Three common types of oblong or rectangular stacks.

(Source: Measuring Hay in Stacks, USDA Leaflet No. 72.)

The answer is secured as follows:

a. Volume = (0.04 x 60) - (0.012 x 100) x $(100)^2$ = 12,000 cubic feet.

b. Table 1 shows that there are about 470 cubic feet per ton of settled alfalfa.

c. 12,000 ÷ 470 = 25.5 tons of hay.

Indoor hay and straw storage helps preserve quality and reduce dry-matter losses. Store hay and straw near loading or feeding areas. Use hay storage sheds according to the following chart.

Hay shed capacities.*

Shed Width	Small Square Bale	Chopped Hay
(ft)	ton/ft of length	
24	2.0	1.9
30	2.6	2.3
36	3.1	2.8
40	3.4	3.1
48	4.0	3.7

* Shed has 20' high side walls.

Rather Use a Computer or Your Smartphone?

This publication contains a variety of weights and measures most commonly used in agriculture. It is by no means a complete list, but it is intended to be a handy guide all under one cover for your desktop reference or for the vehicle glove box. However, do you have times when you would rather use your computer or smartphone?

Many programs or apps are available for purchase and free if you have an Internet service provider or data package. For your computer, simply use your favorite browser and search engine. If using your Android, iPhone, Blackberry or Windows smartphone, go to markets and search with the key words "convert for windows" or "converter." You have many options from which to choose.

While you likely will get better support from a "paid" version, many of the free programs are worthwhile and easy to use. These programs and apps typically will convert the most popular units of distance, temperature, volume, time, speed, mass, power, density, pressure, energy and currency, plus some have the ability to create custom conversions. But keep a copy of this reference because it has calculations you are not likely to find easily elsewhere.

Table 2. Volume of round stacks of hay of specified dimensions. (Volume figures given to the nearest 5.)

Table continues on page 5.

	Indicated Volume in Cubic Feed When the Over is . . .												
Circumference	25 feet	26 feet	27 feet	28 feet	29 feet	30 feet	31 feet	32 feet	33 feet	34 feet	35 feet	36 feet	37 feet
(feet)													
45	825	960	1,090										
46	840	975	1,105	1,235									
47	855	990	1,120	1,250	1,385	1,505							
48	870	1,005	1,135	1,265	1,400	1,525	1,650	1,785					
49	885	1,020	1,150	1,285	1,420	1,540	1,670	1,805	1,935				
50	900	1,035	1,165	1,300	1,435	1,560	1,690	1,825	1,955	2,090	2,215		
51	915	1,050	1,180	1,315	1,450	1,580	1,710	1,845	1,980	2,110	2,240	2,370	2,495
52	930	1,065	1,200	1,330	1,465	1,600	1,730	1,865	2,000	2,130	2,265	2,400	2,530
53	945	1,080	1,215	1,345	1,485	1,615	1,750	1,880	2,020	2,155	2,290	2,430	2,560
54	960	1,095	1,230	1,360	1,500	1,630	1,770	1,900	2,040	2,180	2,320	2,460	2,595
55	975	1,110	1,245	1,380	1,515	1,650	1,790	1,920	2,065	2,205	2,345	2,490	2,630
56	990	1,125	1,260	1,395	1,530	1,665	1,810	1,940	2,085	2,230	2,375	2,520	2,660
57	1,005	1,140	1,275	1,410	1,550	1,685	1,830	1,960	2,105	2,250	2,400	2,545	2,695
58	1,020	1,155	1,290	1,435	1,565	1,705	1,850	1,980	2,125	2,275	2,425	2,575	2,725
59	1,035	1,170	1,310	1,450	1,580	1,720	1,865	2,000	2,150	2,300	2,455	2,605	2,755
60	1,050	1,185	1,325	1,465	1,600	1,740	1,885	2,020	2,170	2,325	2,480	2,635	2,790
61	1,065	1,200	1,340	1,485	1,615	1,760	1,905	2,040	2,195	2,345	2,510	2,665	2,825
62	1,080	1,215	1,355	1,500	1,635	1,775	1,925	2,060	2,215	2,365	2,535	2,695	2,855
63	1,095	1,230	1,370	1,515	1,655	1,795	1,945	2,080	2,235	2,390	2,560	2,725	2,890
64	1,110	1,245	1,385	1,530	1,670	1,810	1,960	2,100	2,260	2,415	2,585	2,755	2,920
65	1,125	1,260	1,400	1,545	1,685	1,830	1,980	2,120	2,280	2,440	2,615	2,780	2,950
66	1,140	1,275	1,420	1,560	1,705	1,850	2,000	2,140	2,300	2,465	2,640	2,810	2,985
67	1,155	1,290	1,435	1,575	1,720	1,865	2,020	2,160	2,325	2,485	2,665	2,840	3,015
68	1,170	1,305	1,450	1,595	1,740	1,885	2,040	2,180	2,345	2,510	2,690	2,870	3,050
69	1,185	1,320	1,465	1,610	1,755	1,905	2,055	2,200	2,365	2,530	2,715	2,900	3,080
70	1,200	1,335	1,480	1,625	1,770	1,925	2,075	2,220	2,385	2,555	2,745	2,930	3,115
71	1,215	1,350	1,495	1,640	1,790	1,940	2,095	2,240	2,405	2,580	2,770	2,960	3,145
72	1,230	1,365	1,515	1,660	1,805	1,960	2,115	2,260	2,430	2,605	2,795	2,990	3,175
73	1,245	1,380	1,530	1,675	1,820	1,975	2,135	2,280	2,450	2,625	2,825	3,015	3,210
74	1,260	1,395	1,545	1,690	1,840	1,995	2,150	2,300	2,470	2,650	2,850	3,045	3,245
75		1,410	1,560	1,705	1,855	2,010	2,170	2,320	2,495	2,675	2,875	3,075	3,275
76		1,425	1,575	1,725	1,870	2,030	2,190	2,340	2,515	2,695	2,905	3,105	3,310
77			1,590	1,740	1,890	2,050	2,210	2,360	2,540	2,720	2,930	3,135	3,340
78			1,605	1,755	1,905	2,070	2,230	2,380	2,560	2,745	2,955	3,165	3,375
79				1,775	1,925	2,090	2,250	2,400	2,580	2,765	2,980	3,195	3,405
80				1,790	1,945	2,105	2,270	2,420	2,605	2,790	3,010	3,225	3,440
81				1,805	1,960	2,125	2,285	2,440	2,625	2,815	3,035	3,255	3,470
82				1,820	1,975	2,145	2,305	2,460	2,645	2,835	3,060	3,280	3,500
83					1,995	2,160	2,325	2,480	2,665	2,860	3,090	3,310	3,535
84						2,180	2,345	2,500	2,690	2,880	3,115	3,340	3,570
85								2,520	2,710	2,905	3,140	3,370	3,600
86									2,735	2,930	3,170	3,400	3,635
87											3,195	3,430	3,665
88												3,460	3,700
89												3,490	3,730
90													3,765
91													
92													
93													
94													
95													
96													
97													
98													

	Indicated Volume in Cubic Feed When the Over is . . .												
Circumference	38 feet	39 feet	40 feet	41 feet	42 feet	43 feet	44 feet	45 feet	46 feet	47 feet	48 feet	49 feet	50 feet
(feet)													
45													
46													
47													
48													
49													
50													
51													
52	2,665	2,795											
53	2,700	2,835	2,975										
54	2,735	2,875	3,015	3,160									
55	2,770	2,915	3,060	3,210	3,360	3,505							
56	2,805	2,955	3,105	3,255	3,415	3,565	3,720						
57	2,845	2,995	3,150	3,305	3,465	3,625	3,785	3,940					
58	2,880	3,035	3,195	3,350	3,515	3,680	3,850	4,010	4,175				
59	2,915	3,075	3,235	3,400	3,570	3,740	3,915	4,080	4,245	4,415			
60	2,950	3,115	3,280	3,445	3,625	3,795	3,975	4,150	4,320	4,490	4,670		
61	2,985	3,155	3,325	3,495	3,675	3,855	4,040	4,215	4,390	4,570	4,750	4,925	
62	3,020	3,195	3,365	3,540	3,730	3,915	4,105	4,285	4,465	4,650	4,830	5,015	5,200
63	3,055	3,235	3,410	3,585	3,780	3,970	4,165	4,355	4,540	4,730	4,910	5,105	5,295
64	3,090	3,275	3,455	3,635	3,835	4,030	4,230	4,425	4,615	4,805	4,995	5,195	5,390
65	3,125	3,315	3,495	3,680	3,885	4,085	4,290	4,490	4,690	4,885	5,075	5,285	5,485
66	3,160	3,355	3,540	3,730	3,935	4,145	4,355	4,560	4,760	4,960	5,160	5,370	5,580
67	3,195	3,395	3,585	3,780	3,990	4,205	4,420	4,630	4,830	5,040	5,245	5,460	5,670
68	3,230	3,430	3,630	3,825	4,045	4,265	4,485	4,695	4,900	5,120	5,330	5,550	5,765
69	3,265	3,470	3,670	3,875	4,095	4,320	4,545	4,760	4,970	5,195	5,415	5,640	5,860
70	3,300	3,510	3,715	3,920	4,150	4,375	4,610	4,825	5,045	5,275	5,495	5,730	5,955
71	3,335	3,550	3,760	3,970	4,205	4,435	4,670	4,895	5,120	5,355	5,580	5,820	6,050
72	3,375	3,590	3,805	4,015	4,255	4,495	4,735	4,965	5,195	5,435	5,665	5,910	6,145
73	3,410	3,630	3,845	4,065	4,310	4,550	4,795	5,030	5,270	5,515	5,750	6,000	6,240
74	3,445	3,665	3,890	4,110	4,360	4,610	4,855	5,095	5,340	5,595	5,835	6,090‘	6,335
75	3,480	3,705	3,935	4,160	4,415	4,670	4,915	5,165	5,415	5,675	5,915	6,180	6,430
76	3,515	3,745	3,975	4,205	4,465	4,725	4,980	5,235	5,490	5,750	6,000	6,270	6,525
77	3,550	3,785	4,020	4,250	4,520	4,785	5,045	5,305	5,560	5,830	6,085	6,355	6,620
78	3,585	3,825	4,065	4,300	4,570	4,840	5,105	5,370	5,635	5,910	6,170	6,445	6,715
79	3,620	3,865	4,105	4,345	4,625	4,895	5,170	5,440	5,710	5,990	6,255	6,535	6,810
80	3,655	3,905	4,150	4,395	4,675	4,955	5,235	5,510	5,785	6,070	6,340	6,625	6,905
81	3,690	3,945	4,195	4,440	4,730	5,010	5,295	5,575	5,855	6,145	6,425	6,715	7,000
82	3,725	3,985	4,240	4,490	4,785	5,070	5,360	5,645	5,930	6,225	6,510	6,800	7,090
83	3,760	4,025	4,280	4,535	4,830	5,130	5,425	5,715	6,005	6,305	6,595	6,890	7,185
84	3,795	4,065	4,325	4,580	4,885	5,190	5,485	5,785	6,080	6,385	6,675	6,980	7,280
85	3,830	4,105	4,365	4,630	4,935	5,245	5,550	5,850	6,155	6,465	6,760	7,070	7,375
86	3,865	4,145	4,410	4,675	4,990	5,300	5,615	5,920	6,230	6,545	6,845	7,160	7,470
87	3,900	4,185	4,455	4,725	5,040	5,360	5,680	5,990	6,300	6,620	6,930	7,250	7,565
88	3,940	4,220	4,500	4,770	5,090	5,420	5,745	6,060	6,375	6,700	7,015	7,340	7,660
89	3,975	4,260	4,540	4,815	5,145	5,475	5,805	6,125	6,450	6,780	7,100	7,430	7,755
90	4,010	4,300	4,585	4,860	5,200	5,535	5,865	6,195	6,525	6,860	7,185	7,520	7,845
91	4,045	4,340	4,630	4,910	5,250	5,595	5,930	6,265	6,600	6,940	7,270	7,605	7,940
92	4,080	4,380	4,670	4,955	5,305	5,650	5,995	6,335	6,674	7,020	7,355	7,695	8,035
93		4,420	4,715	5,005	5,360	5,710	6,055	6,400	6,750	7,095	7,440	7,785	8,130
94		4,460	4,760	5,050	5,410	5,765	6,120	6,470	6,825	7,175	7,525	7,875	8,225
95			4,805	5,100	5,465	5,825	6,180	6,540	6,895	7,255	7,610	7,965	8,320
96				5,150	5,515	5,885	6,245	6,610	6,970	7,335	7,695	8,055	8,415
97				5,195	5,570	5,945	6,310	6,680	7,045	7,415	7,780	8,145	8,510
98					5,625	6,000	6,370	6,750	7,120	7,495	7,865	8,285	8,605

From USDA Leaflet No. 72, P. 5, Table 4.

Bunker/Trench Silos and Silage Piles

Wet Forages

Approximate dry-matter capacities of bunker silos

■ **Haycrop Silage**

Dry-matter density is assumed to be 11.8 lbs DM/ft^3 *(Rotz, 1989)*.

■ **Corn Silage**

Dry-matter density is assumed to be 17.7 lbs DM/ft^3 (Holter, 1983).

$$\text{Capacity, tons DM} = \frac{(\text{length, ft}) \times (\text{width, ft}) \times (\text{average height, ft}) \times (\text{dry matter density})}{2000}$$

Table 3. Horizontal silo capacity, wet tons.*

	Silo Floor Width (ft)								
Depth	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
(feet)	**wet tons/10' length**								
10	40	60	80	100	120	140	160	180	200
12	50	70	95	120	145	170	190	215	240
14	55	85	110	140	170	195	225	250	280
16	65	95	130	160	190	225	255	290	320
18	70	110	145	180	215	250	290	325	360
20	80	120	160	200	240	280	320	360	400

* 65% moisture; 40 lb/ft^3 or 50 ft^3 = 1 ton; 1.25 ft^3/bu. Silo assumed level full. Capacities rounded to nearest 5 tons. To calculate capacity of other silo sizes: (silage depth, ft x silo width, ft x silo length, ft) ÷ 50.

Table 4. Horizontal silo capacity, dry matter.*

	Silo Floor Width (ft)								
Depth	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
feet	**tons dry matter/10' length**								
10	15	20	30	35	40	50	55	65	70
12	15	25	35	40	50	60	65	75	85
14	20	30	40	50	60	70	80	90	100
16	20	35	45	55	65	80	90	100	110
18	25	40	50	65	75	90	100	115	125
20	30	40	55	70	85	100	110	125	140

* Silo assumed level full. Capacities rounded to nearest 5 tons.

Table 5. Capacity in tons per foot of corn and grass silage for trench or bunker silos.

Average Width	Depth																	
	5 Feet			6 Feet			7 Feet			8 Feet			9 Feet			10 Feet		
	Cubic Feet	Tons Corn	Tons Grass	Cubic Feet	Tons Corn	Tons Grass	Cubic Feet	Tons Corn	Tons Grass	Cubic Feet	Tons Corn	Tons Grass	Cubic Feet	Tons Corn	Tons Grass	Cubic Feet	Tons Corn	Tons Grass
(Feet)																		
8	40	.70	.90	48	.84	1.08	56	.98	1.26	64	1.12	1.44	72	1.25	1.62	80	1.40	1.80
10	50	.88	1.13	60	1.05	1.35	70	23	1.58	80	1.40	1.80	90	1.58	2.03	100	1.75	2.25
12	60	1.05	1.35	72	1.26	1.62	84	1.47	1.89	96	1.68	2.16	108	1.69	2.48	120	2.10	2.70
14	70	1.23	1.58	84	1.47	1.69	98	1.71	2.21	112	1.96	2.52	126	2.21	2.84	140	2.45	3.15
16	80	1.40	1.80	96	1.68	2.16	112	1.96	2.52	128	2.24	2.88	144	2.52	3.24	160	2.80	3.60
18	90	1.58	2.03	108	1.89	2.48	126	2.21	2.89	144	2.52	3.24	162	2.89	3.64	180	3.15	4.05
20	100	1.75	2.25	120	2.10	2.70	140	2.45	3.15	160	2.80	3.60	180	3.15	4.05	200	3.50	4.50
22	110	1.93	2.48	132	2.31	2.97	154	2.69	3.47	176	3.08	3.96	198	3.47	4.45	220	3.85	4.95
24	120	2.10	2.70	144	2.52	3.24	168	2.94	3.78	192	3.36	4.32	216	3.78	4.85	240	4.20	5.40
26	130	2.28	2.92	156	2.73	3.51	182	3.19	4.09	208	3.64	4.68	234	4.10	5.26	260	4.55	5.85
28	140	2.45	3.15	168	2.94	3.78	196	3.43	4.41	224	3.92	5.04	252	4.41	5.67	280	4.90	6.30
30	150	2.63	3.38	180	3.15	4.05	210	3.68	4.73	240	4.20	5.40	270	4.73	6.05	300	5.25	6.75

Capacity in cubic feet = [(top width + bottom width) ÷ 2] x height x length.

Capacity in tons, corn or sorghum (35 pounds per cubic foot = capacity cubic feet ÷ 60.

Grass silage (40 pounds per cubic foot) = capacity cubic feet ÷ 50.

Table 6. Quantity in silage piles.

Depth	Average pile width (ft)					
	24	28	32	36	38	42
(feet)	——— tons dry matter/10' length ———					
4	6	7	8	9	9	10
5	7	8	10	11	11	13
6	9	10	12	13	14	15
7	10	12	13	15	16	18

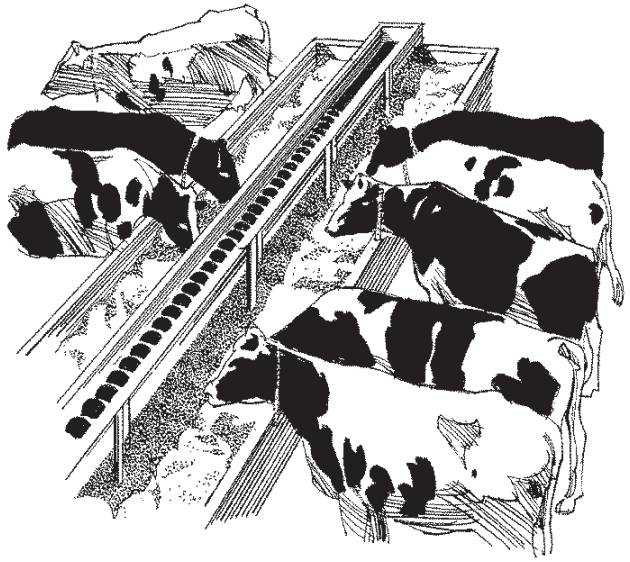


Table 7. Silo capacity chart.

Size of Silo	Cubic Feet in Silo	Dry Matter	70% Corn Silage	60% Corn or Grass Silage	50% Grass Silage	40% Grass Silage	15.5% Cracked Shelled Corn		24% Cracked Shelled Corn		30% Cracked Shelled Corn		24% Ground Ear Corn		28% Ground Ear Corn		32% Ground Ear Corn	
		tons					bushels	tons	bushels	tons	bushels	tons	bushels	tons	bushels	tons	bushels	tons
12 x 30	3,390	21	70	52	42	35	2,712	76	2,511	78	2,354	80	1,576	65	1,507	67	1,449	69
12 x 40	4,520	32	106	80	64	53	3,616	101	3,348	105	3,138	106	2,101	87	2,009	90	1,932	91
12 x 50	5,650	44	147	110	88	73	4,520	126	4,185	131	3,923	133	2,627	109	2,511	112	2,415	114
14 x 30	4,620	29	96	72	58	48	3,696	103	3,422	107	3,208	109	2,148	89	2,053	92	1,974	93
14 x 40	6,160	44	145	110	88	73	4,928	129	4,562	143	4,277	145	2,865	119	2,738	122	2,632	124
14 x 50	7,700	60	200	150	120	100	6,160	173	5,703	178	5,347	181	3,581	148	3,422	153	3,291	156
14 x 60	9,240	78	260	195	156	130	7,392	207	6,844	214	6,416	218	4,297	178	4,107	183	3,949	187
16 x 30	6,030	38	125	95	76	63	4,824	135	4,466	140	4,187	142	2,804	116	2,680	120	2,577	122
16 x 40	8,040	57	189	142	114	95	6,432	180	5,955	186	5,583	189	3,739	155	3,573	159	3,436	163
16 x 50	10,050	78	261	195	156	130	8,040	225	7,44	232	6,979	237	4,674	194	4,467	199	4,295	203
16 x 60	12,060	102	341	255	204	170	9,648	270	8,933	279	8,375	284	5,609	232	5,360	239	5,154	244
18 x 40	10,160	72	239	180	144	120	8,128	228	7,525	235	7,055	239	4,726	196	4,516	201	4,342	205
18 x 50	12,700	99	330	247	198	165	10,160	285	9,407	294	8,819	299	5,907	245	5,644	252	5,427	257
18 x 60	15,240	129	430	322	258	215	12,192	341	11,288	353	10,583	359	7,088	293	6,773	302	6,513	308
18 x 70	17,780	162	539	405	324	270	14,224	398	13,170	412	12,347	419	8,270	342	7,902	352	7,598	359
20 x 40	12,560	89	295	222	178	148	10,048	281	9,303	291	8,722	296	5,842	242	5,582	249	5,367	254
20 x 50	15,700	122	407	305	244	203	12,560	352	11,629	363	10,902	370	7,302	302	6,978	311	6,709	317
20 x 60	18,840	159	529	397	318	265	15,072	422	13,955	436	13,083	443	8,763	362	8,373	373	8,051	381
20 x 70	21,980	198	660	495	396	330	17,584	492	16,280	509	15,263	517	10,223	423	9,769	436	9,393	444
22 x 40	15,200	107	358	267	214	178	12,160	341	11,259	352	10,55	358	7,070	293	6,756	301	6,496	307
22 x 50	19,000	148	492	370	296	246	15,200	426	14,074	440	13,194	447	8,837	366	8,444	377	8,119	384
22 x 60	22,800	192	640	480	384	320	18,240	511	16,888	528	15,833	537	10,605	439	10,133	452	9,744	461
24 x 50	22,600	175	583	437	350	291	18,080	506	16,740	523	15,694	532	10,512	435	10,044	448	9,658	457
24 x 60	27,120	228	760	570	456	380	21,696	608	20,088	628	18,833	638	12,614	522	12,053	538	11,590	548
24 x 70	31,640	284	947	710	568	473	25,312	709	23,347	732	21,972	745	14,716	609	14,062	627	13,521	640
24 x 80	36,160	341	1,136	852	682	568	28,928	810	26,785	837	25,111	851	16,819	969	16,071	717	15,453	731
26 x 50	26,500	206	688	515	412	343												
26 x 60	31,800	273	910	682	546	455	56 pounds per bushel		62.5 pounds per bushel		67.8 pounds per bushel		82.8 pounds per bushel		89.2 pounds per bushel		94.6 pounds per bushel	
26 x 70	37,100	343	1,143	857	686	571												
26 x 80	42,400	417	1,389	1,042	834	695												
28 x 60	36,900	309	1,030	772	618	515	1.25 cubic feet per bushel		1.35 cubic feet per bushel		1.44 cubic feet per bushel		2.15 cubic feet per bushel		2.25 cubic feet per bushel		2.34 cubic feet per bushel	
28 x 70	43,050	383	1,275	957	766	638												
28 x 80	49,200	461	1,537	1,153	922	768												
30 x 50	35,300	274	913	685	548	456												
30 x 60	42,360	357	1,190	892	714	595												
30 x 70	49,420	441	1,470	1,102	882	735												
30 x 80	56,480	529	1,764	1,322	1,058	881												

Source: Madison Silo, Division of Martin Marietta Corp. (Madison Silo Capacity Chart - Corn Silage-Grass Silage).

Silage Bag Capacity

One way to establish this value is to calculate the volume in the bag and multiply by its density. The volume of a round bag is calculated as:

$V = \pi \times (D^2 \div 4) \times L$

where $\pi = 3.14$, V = Volume (ft^3), D = Diameter (ft), and L = Length of silage (ft).

When full-length bags are used, the length of the silage is the bag length minus the unused portion needed to seal each end of the bag.

The quantity of dry matter in the bag is the volume multiplied by the dry matter density. The dry matter density can vary from bag to bag and is based on machine type and adjustment, as well as forage type. Typical corn silage densities range between 11 and 15 pounds DM per cubic foot. Table 8 shows silo bag capacity based on the following assumptions: round bags, silage length = bag length – (2 x diameter), density = 13 pounds DM per cubic foot.

Use the multiplier in Table 9 to adjust the values in Table 8 for a different density.

For example, the quantity of silage in a 200-foot x 9-foot bag packed to 15 pounds of dry matter per cubic foot is:

150,500 lbs DM x 1.15 = 173,100 lbs DM.

Table 8 lists dry matter in one bag. If you need to know the capacity in pounds of silage as fed, divide the table value by the dry matter content.

For example, 65 percent moisture silage in a 200-foot-long bag of 9-foot diameter weighs:

430,000 lbs as fed = 150,500 lbs DM ÷ 0.35

when packed at 13 pounds dry matter per cubic foot density. Divide this value by 2,000 pounds per ton to obtain 215 tons as fed (TAF).

Source: Brian J. Holmes, University of Wisconsin-Madison.

Table 8. Capacities of silage bags at 13 pounds dry matter per cubic foot density.

	Bag Diameter							
	8 feet		9 feet		10 feet		12 feet	
Bag Length	Silage Length	Capacity	Silage Length	Capacity	Silage Length	Capacity	Silage Length	Capacity
(ft)	(ft)	(lbs DM)	(ft)	(lbs DM)	(ft)	(lbs DM)	(ft)	(lbs DM)
100	84	54,900	82	67,800	80	81,700	76	111,700
150	134	88,600	132	109,200	130	132,700	126	185,300
200	184	120,200	182	150,500	180	183,800	176	258,800
250	234	152,900	232	191,900	230	234,800	226	332,300
300	284	185,600	282	233,200	280	285,900	276	405,800

Table 9. Multiplier to adjust Table 8 capacities to a different density.

Density	Multiplier
(lbs DM/ft^3)	
11	0.85
12	0.92
13	1.00
14	1.08
15	1.15

Table 10. Silage bag capacities.*

Bag Diameter	Bag Length	Hay Silage	Corn Silage	Ground Ear Corn	Ground Shelled Corn	Shelled Corn
(feet)	(feet)	(tons)	(tons)	(bu)	(bu)	(bu)
8	100	80-90	90-100	2,000	3,100	2,600
	150	120-140	140-150	3,200	5,000	4,100
	200	170-180	190-200	4,300	6,800	5,735
9	135	120-140	130-160	3,500	5,500	4,300
	150	150-170	160-190	3,900	6,100	4,800
	200	190-210	220-240	5,300	8,400	6,600
10	150	240-260	260-280	6,000	9,400	7,400
	200	300-320	345-365	8,200	13,000	10,000
	250	375-395	430-455	10,250	16,250	12,500
12	200	360	410			
	250	440	520			
	300	530	620			

* These quantities are only approximations. Silage weights are as-fed wet weight. Actual silage quantities will vary with moisture content, length of cut and density. Dry matter density in table is 13 pounds per cubic foot.

Source: Table 9-10, MWPS-7 "Dairy Freestall Housing and Equipment" Seventh Edition 2000

Table 11. Grain moisture factor (GMF).

% Moisture	GMF
18	1.03
20	1.06
22	1.08
24	1.11
26	1.14
28	1.17
30	1.21
32	1.24
34	1.28
36	1.32
38	1.36
40	1.41
45	1.54
50	1.69

To convert wet tons to tons at 15.5% moisture, divide by GMF. To convert tons at 15.5% moisture to wet tons, multiply by GMF.

GMF = 84.5 ÷ (100 - % moisture).

Table 12. Adding water to whole-plant corn silage or haylage.

Initial Moisture	Desired Final Moisture (%)					
	56	58	60	62	64	66
(%)	pounds of water to add per ton					
54	91	190	300	421	556	706
56		95	200	316	444	588
58			100	210	333	471
60				105	222	352
62					111	235
64						188

1 gallon of water = 8.33 lbs.

Tower Silos

Table 13. Concrete silo capacities for corn silage.

Diameter and Settled Depth	% moisture 40	50	60	70
	tons			
12 x 30	47	54	62	74
12 x 40	66	75	87	103
12 x 50	85	97	111	132
14 x 40	93	106	121	143
14 x 50	121	137	158	185
14 x 55	134	153	175	210
16 x 50	163	184	210	250
16 x 60	200	230	260	300
16 x 65	220	250	280	330
18 x 50	210	240	270	320
18 x 60	260	290	340	390
18 x 70	310	350	400	460
20 x 60	330	370	420	490
20 x 70	390	440	500	580
20 x 80	460	510	580	670
24 x 60	490	540	620	710
24 x 70	580	650	740	850
24 x 80	680	760	850	980
24 x 90	780	860	970	1,110
30 x 80	1,090	1,280	1,480	1,630
30 x 90	1,240	1,480	1,710	1,880

Table 14. Steel silo capacities for alfalfa silage.

Diameter and Settled Depth	% moisture 40	50	60	70
	tons			
12 x 30	37	47	62	89
12 x 40	54	67	88	127
12 x 50	69	87	116	166
14 x 40	75	94	123	177
14 x 50	98	123	163	230
14 x 55	110	138	183	260
16 x 50	132	165	220	310
16 x 60	165	210	270	390
16 x 65	183	230	300	430
18 x 50	171	210	280	400
18 x 60	210	270	350	500
18 x 70	260	330	430	610
20 x 60	270	340	450	630
20 x 70	330	410	540	760
20 x 80	390	490	630	890
24 x 60	410	510	660	930
24 x 70	490	620	800	1,120
24 x 80	590	730	940	1,310
24 x 90	680	840	1,090	1,500
30 x 80	960	1,180	1,520	2,090
30 x 90	1,110	1,370	1,750	2,390

Table 15. Approximate tons of dry matter in next 4 feet of silage in top-unloading tower silos during unloading.
(This information is used in determining removal rates.)

Depth of silage already unloaded	Silo Diameter (ft) 10	12	14	16	18	20	22	24	26	28	30
(ft)											
0	1	2	2	3	4	5	6	7	8	9	10
4	1	2	3	4	5	6	7	8	10	11	13
8	2	2	3	4	5	7	8	10	11	13	15
12	2	3	4	5	6	8	9	11	13	15	17
16	2	3	4	5	7	9	10	12	14	16	18
20	2	3	5	6	7	10	12	14	16	18	22
24	3	4	5	7	9	11	13	15	18	21	23
28	3	4	5	7	9	11	14	16	19	22	26
32	3	5	6	8	10	12	14	17	20	23	27
36	3	5	6	8	10	12	15	18	21	23	27
40			7	8	10	13	16	19	22	27	30
44			7	9	11	13	17	20	23	27	31
48			7	9	12	13	17	20	24	27	31
52			7	9	12	14	17	21	24	27	33
56			7	10	12	15	18	21	25	28	33
60			7		13	15	18	21	25	31	34
64					13	16	18	21	26	30	34
68								21	26	30	33
72								21	26	27	31
76								21	26	28	31

Converting Forage Yields to a Common Moisture

■ Adjusting forage yields to 65 percent or 70 percent moisture so yields can be compared fairly is common. To do so, the following formula can be used:

$$\text{adjusted yield} = \frac{\text{yield (as harvested)} \times \%\ \text{dry matter (as harvested)}}{\%\ \text{dry matter adjusting to}}$$

Note: Work with dry matter percent, not moisture percent.

Example A: 21.3 tons of forage at 61% moisture (39% dry matter) is harvested per acre. What is the yield in tons/acre adjusted to 65% moisture?

$$\text{yield at 65\% moisture (35\% DM)} = \frac{21.3 \times 39}{35} = \textbf{23.7 tons/acre at 35\% DM}$$

Example B: What would be the yield adjusted to 30% DM?

$$\text{yield at 70\% moisture (30\% DM)} = \frac{21.3 \times 39}{30} = \textbf{27.7 tons/acre at 30\% DM}$$

Example C: What would be the yield adjusted to 100% DM?

$$\text{yield at 100\% DM} = \frac{21.3 \times 39}{100} = \textbf{8.3 tons/acre at 100\% DM}$$

Table 16. Dry-matter factor (DMF).

% Moisture	DMF
30	1.43
40	1.67
50	2.00
55	2.22
60	2.50
65	2.86
70	3.33
75	4.00
80	5.00

To convert from wet tons to dry matter, divide by the DMF.

To convert from tons of dry matter to wet tons, multiply by the DMF.

DMF = 100 ÷ (100 - % moisture).

Table 17. Storage capacity for round grain bins.*

Diameter	Depth of Grain (ft)				
	1	11	13	16	19
(ft)	bushels				
14	125	1,375	1,625	2,000	2,375
18	203	2,200	2,635	3,250	3,850
21	277	3,050	3,600	4,400	5,300
24	362	4,000	4,700	5,800	6,900
27	458	5,050	5,950	7,300	8,700
30	565	6,215	7,345	9,040	10,735
36	814	8,950	10,600	13,000	15,450
40	1,005	11,050	13,050	16,100	19,100

* Capacity does not include space above eave line. Based on 1.25 ft³/bushel.

Source: MWPS-6 Beef Housing and Equipment Handbook, 4th Ed.

Table 18. Approximate capacity of round, hopper-bottom bins.*

Description	Overall Height	Capacity in Tons (lb/ft³ material)			Total Capacity	
	(ft)	30	40	50	ft³	bu
6' diameter center draw-off	10-10½	2.2	2.7	3.4	135	108
	10½-13	3.1	4.2	5.3	210	166
	15½-16	4.2	5.7	7.1	285	228
	18-18½	5.4	7.2	9.0	360	288
	20-20½	6.2	8.6	10.4	415	322
6' diameter side draw-off	14½-15	2.8	3.7	4.7	187	150
	17-17½	3.9	5.2	6.6	263	210
	19½-20	5.0	6.7	8.4	338	270
	22½-23	6.1	8.2	10.3	413	330
	25-25½	7.3	9.7	12.1	487	390
9' diameter center draw-off	16½-17	8.4	11.2	14.0	561	413
	19½-20	11.0	14.6	18.3	730	583
	22-22½	13.5	18.0	22.5	900	720
	24½-25	16.0	21.3	26.7	1,067	853
	27½-28	18.6	24.7	30.9	1,236	990
12' diameter center draw-off	20-20½	16.3	21.7	27.1	1,085	870
	22½-23	20.7	27.7	34.6	1,383	1,110
	25½-26	25.2	33.6	42.0	1,681	1,345
	28-28½	29.7	39.6	49.5	1,980	1,585
	30-30½	34.2	45.6	57.0	2,278	1,820
	33-33½	38.7	51.5	64.4	2,577	2,060
	36-36½	43.1	57.5	71.9	2,875	2,300
	38½-39	47.6	63.5	79.3	3,174	2,540
	41½-42	52.0	69.4	86.8	2,472	2,780

* 60° hopper; 24" slide valve clearance.

For estimates on flat storage calculations, see MWPS-13, pages 42 and 43.

GRANULAR MATERIAL

Calculating Capacity

Grain weight in a bin

Sometimes stockmen need to estimate the weight of grain in storage. The grain weight is the volume multiplied by the density (pounds per bushel or cubic foot). **Tables 19 and 20** list the densities.

Such estimates are difficult to make because of differences in moisture content, test weight depth of material stored and other factors. However, the following procedure will enable you to figure feed quantities fairy closely.

1. **Corn (shelled) or small grain in rectangular cribs or bins.**
   Multiply the *width* by the *length* by the average *depth* (all in feet) and multiply by 0.8 to get the number of bushels (multiplying by 0.8 is the same as dividing by 1¼ the number of cubic feet in a bushel).

2. **Ear corn in rectangular cribs or bins.**
   Multiply the *width* by the *length* by the average *depth* (all in feet) and multiply by 0.4 to get the number of bushels (multiplying by 0.4 is the same as dividing by 2½ the number of cubic feet in a bushel of ear corn).

3. **Round bins or cribs.**
   To find the cubic feet in a cylindrical bin, multiply the *squared radius* by π (3.1416) by the depth.

   [diameter = circumference divided by π]

   Thus, the volume of a round bin 20 feet in diameter and 10 feet deep is determined as follows:

   a. The radius is half the diameter, or 10 feet

   b. 10 x 10 = 100 (squared radius)

   c. 100 x 3.1416 = 314.16

   d. 314.16 x 10 = 3,141.6 cubic feet

   e. Where shelled corn or small grain is involved, you would multiply 3,141.6 x 0.8, which equals 2,513.28 bushels of grain that it would hold if full.

   f. Where ear corn is involved, you would multiply 3,141.6 x 0.4, which equals 1,256.64 bushels of ear corn that it would hold if full.

Figuring Grain Storage Capacity

- 1 bushel ear corn = 70 lbs, 2.5 cubic feet (15.5% moisture)
- 1 bushel shelled corn = 56 lbs, 1.25 cubic feet (15.5% moisture)
- 1 cubic foot = 1/2.50 = .4 bushel of ear corn
- 1 cubic foot = 1/1.25 = .8 bushel of shelled corn
- $feet^3$ = bushel x 1.25
- bushel = $feet^3$ x .8

■ Rectangular or square cribs or bins

cubic feet = width x height x length (W x H x L)

■ Round cribs, bins or silos

volume = $\pi R^2H = \pi D^2H/r$

cubic feet = π x R x R x H

cubic feet = π x H x D x D/4

cubic feet = 0.785 x D x D x H

R = radius, H = height, D = Diameter, π = 3.1416

Examples:

1. crib – ear corn - 6' wide x 12' high x 40' long
   a. 6 x 12 x 40 = 2,880 cubic feet x
      0.4 bushels/cubic foot = 1,152 bushels

2. round crib – ear corn – 14' diameter x 13' high
   a. 0.785 x 14 x 14 x 13 x 0.4 = 800 bushels

3. round bin or silo – shell corn – 14' diameter x 13' high
   a. .785 x 14 x 13 x 0.8 = 1,600 bushel

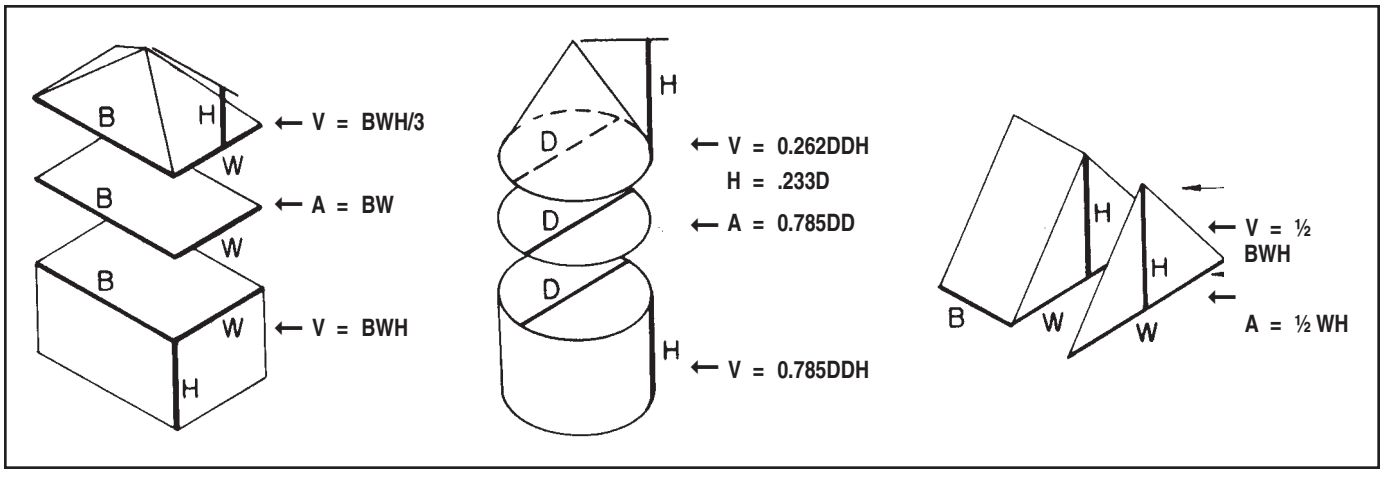


Figure 2. Formulas for calculating areas and volumes.

(Source: Midwest Planning Service – 13.)

Sizing Commodity Storages

In most cases, the amount of storage needed for a particular ingredient will be a multiple of the unit truck capacity, plus a cushion of 25 percent to 50 percent, depending on purchasing and transportation arrangements.

A semi-trailer's capacity is about 24 tons. For dense products, such as grain, cottonseed, soybean meal and pelleted ingredients, one truckload nearly will equal the semi's weight capacity. For less dense products, such as brewers' and distillers' grain, experience shows that truck volume is the limiting factor; the load will contain 20 to 22 tons of material.

To determine the commodity storage required for a semi load of soybean meal, assume the semi capacity is 24 tons. Storage needed per ton of soybean meal is 47 ft^3/ton, **Table 24**. Allowing 25 percent extra storage, the storage required for soybean meal is:

24 ton x 47 ft^3/ton x 1.25 = 1,410 ft^3

A 16-foot wide by 30-foot long bay will be filled about 3 feet deep (1,410 ft^3/(30 ft x 16 ft).

Weights and Densities

Table 19. Weights and measures of common feeds.

Feed	Approx. Weight	
	Lb per Quart	Lb per Bushel
Alfalfa meal (13% moisture)	0.6	16-18
Barley	1.5	48
Beet pulp (dried)	0.6	19
Brewers' grain (dried)	0.6	19
Buckwheat	1.6	50
Buckwheat bran	1.0	29
Corn, husked ear (2 measured bushels)	—	70
Corn, cracked	1.6	50
Corn, shelled	1.8	56
Corn meal	1.6	50
Corn-and-cob meal	1.4	45
Cottonseed meal	1.5	48
Cowpeas	1.9	60
Distillers' grain (dried)	0.6	19
Fish meal	1.0	35
Gluten feed	1.3	42
Linseed meal (old process)	1.1	35
Linseed meal (new process)	0.9	29
Milo (grain sorghum)	1.7	56
Molasses feed	0.8	26
Oats (standard but normally heavier)	1.0	32
Oats, ground	0.7	22
Oat middlings	1.5	48
Rice bran	0.8	26
Rye	1.7	56
Sorghum (grain)	1.7	56
Soybeans	1.8	60
Tankage	1.6	51
Wheat	1.9	60
Wheat bran	0.5	16
Wheat middlings, standard	0.8	26
Wheat screenings	1.0	32

Table 20. Approximate weights and density of feeds and grains.

Feed	Pound/ Bushel	Pound/ Cubic Foot	Cubic Feet/Ton
Barley	48	38	53
Shelled corn	56	45	45
Ear corn (double bushel)*	70	28	72
Ear corn (single bushel)	35	28	72
Oats	32	26	77
Potatoes	60	48	42
Rye	56	45	45
Wheat	60	48	42
Soybean oil meal	54	43	47
Poultry feed	35	28	72
Alfalfa meal	—	15	134

* Double measured bushel.

Source: Dairy Reference Manual, College of Agriculture, Pennsylvania State University.

Table 21. Commodity storage densities and storage requirements.

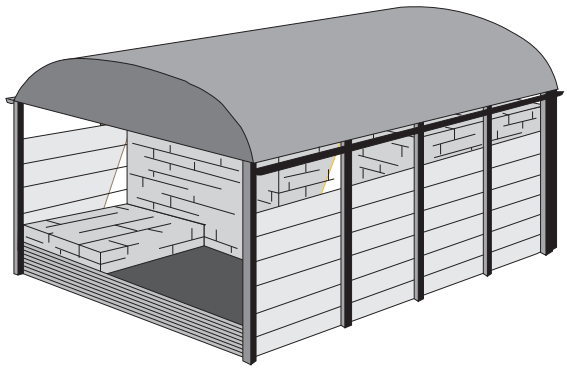
Description	Density	Storage Vol.
	(lb/ft³)	(ft³/ton)
Alfalfa meal, dehydrated, 13%	16-18	111-125
Alfalfa meal, dehydrated, 17%	18-22	91-111
Barley, ground	24-26	77-83
Barley, malt	30-31	65-67
Blood meal	39	52
Bone meal	50-60	33-40
Brewers' dried grain	14-15	133-143
Brewers' grain, spent, dry	25-30	67-80
Brewers' grain, wet	55-60	33-36
Calcium carbonate	75	27
Corn distillers' dried grains	18	111
Corn distillers' dried soluble	25-26	77-80
Corn, whole shelled	45	44
Cottonseed hulls	12	167
Cottonseed oil meal	37-40	50-54
Cottonseed with lint	18-25	80-111
Cottonseed, delinted	25-35	57-80
Dairy concentrates	43	47
Dried beet pulp	11-16	125-182
Dried citrus pulp	21	98
Hay, loose	5	400
Hay, pressed	8	250
Limestone	68	29
Malt sprouts	13-16	125-154
Milo, ground	32-36	56-63
Oats, rolled	19-24	83-105
Oats, whole	25-35	57-80
Phosphate, tricalcium	21	95
Rice, hulls	20-21	95-100
Sorghum, grain	32-35	57-63
Soybean hulls, ground	20	100
Soybean hulls, unground	6-7	286-333
Soybean oil meal (expeller)	36-40	50-56
Soybeans, grain	46-48	42-43
Wheat middlings (std.)	18-25	80-111
Wheat, ground	38-39	51-53

Source: Proceedings: Alternative Feeds for Dairy and Beef Cattle, and American Feed Industry Association publications.

Table 22. Grain conversions.

Grain	Bushels to Metric Tons	Metric Tons to Bushels
	Multiply by	Multiply by
Corn	0.0255	39.286
Soybeans	0.0273	36.667
Wheat	0.0273	36.667
Oats	0.0145	68.750
Rapeseed	0.0227	44.000
Barley	0.0218	45.833
Rye	0.0255	39.286
Flaxseed	0.0255	39.286

A standard bushel is 1.245 ft³ by volume. Because different grains have different standard bushel definitions by weight, a special conversion factor is used for each crop.



APPLICATION

Table 23. Calculating feed inventory.

Table continues on page 18.

Forage | **Stored In**

High moisture corn — Vertical silo

• Shelled

Measure depth of corn in feet. From table, determine number of bushels per foot of silo height based on silo diameter and percentage of moisture.

bushels per foot x depth of stored corn = bushels shelled high moisture corn

Approximate Bushels Per foot of Silo Height

kernel moisture content (%)	Silo Diameter (feet) 10	12	14	16	18	20
SHELLED CORN						
15.5	63	90	123	160	204	251
24	58	84	114	149	188	234
28	56	80	109	143	180	223
32	53	77	105	136	173	214

EXAMPLE: 20' shelled HM corn (28% moisture content) in 14' diameter silo.
From table – 109 bushels/foot x 20' = 2,180 bushels

• Ground ear

Measure depth of corn in feet. From table, determine number of bushels per foot of silo height based on silo diameter and percentage of moisture.

bushels per foot x depth of stored corn = bushels ground high moisture ear corn

Approximate Bushels Per foot of Silo Height

kernel moisture content (%)	Silo Diameter (feet) 10	12	14	16	18	20
GROUND EAR CORN						
15.5	40.5	59	79.5	103	131	162.0
24	37	53	72	93	119	146.0
28	35	50	69	89	113	140
32	34	48	66	86	109	134

EXAMPLE: 30' ground HM ear corn (24% moisture content) in 18' diameter silo.
From table – 119 bushels/foot x 30' = 3,570 bushels

• Dry corn – ear — **Crib**

1. Calculate cubic feet of corn: length x average width x height of grain.
2. Calculate total bushels: 1 cubic foot = .8 bushel

EXAMPLE: 8 feet of corn in crib 4' wide at bottom and 6' wide at the top, 20' long.

1. Calculate bushels of ear corn (above).
2. Two bushels of ear corn = 1 bushel shelled corn.

EXAMPLE: 640 bushels of ear corn as calculated above = 320 bushels of shelled dry corn.

Hay — Stacks

1. Calculate cubic feet: length x width x height
2. Calculate total tons: cubic feet ÷ cubic feet/ton (from table)

Loose Hay	Cubic Feet/Ton
low mow or top of mow	550
average	500
bottom of mow	450
Baled Hay	
loose bales	250-300
tight bales	200-250
Chopped Hay	
long	250-360
short	200-250

EXAMPLE: Stacked bales of hay (medium tight bales) 100' x 40' x 15'.

1. cubic feet hay = 100' x 40' x 15' = 60,000 cubic feet.
2. 60,000 cubic feet ÷ 250 cubic feet/ton = 240 tons baled hay.

Forage	Stored In

Hay crop silage and/or corn silage — **Vertical silo**

Measure settled depth of silage in feet. From table, determine number of tons of dry matter.

Approximate Dry-Matter Capacity of Silos

Depth of Settle Silage	Inside Diameter of Silo in Feet										
	10	12	14	16	18	20	22	24	26	28	30
(feet)	Tons of Dry Matter										
20	8	12	16	21	27	33	40	47	56	65	74
22	9	14	19	24	30	38	48	54	64	74	85
24	11	15	21	27	34	43	52	61	72	83	96
26	12	17	23	30	38	48	58	68	81	94	107
28	13	19	26	35	44	53	64	76	90	104	119
30	15	21	29	38	47	59	71	84	99	115	132
32	16	23	32	41	52	65	78	93	109	127	145
34	18	25	34	45	57	70	85	101	119	137	158
36	19	28	37	48	62	76	92	109	129	150	172
38	21	30	41	53	67	82	100	118	139	161	185
40	22	32	44	57	72	89	107	127	150	173	199
42		34	47	61	77	95	115	137	161	186	214
44		37	50	65	82	102	123	146	172	200	229
46		39	53	69	88	108	131	155	183	212	244
48		42	56	74	93	115	140	166	195	226	260
50		44	60	78	99	122	148	175	206	239	274
52			64	83	105	129	157	186	219	254	291
54			67	88	111	137	165	197	231	267	306
56			71	93	117	144	174	207	243	282	324
58			74	98	123	151	183	218	261	297	339
60			78	102	129	159	192	228	273	309	357
62					135	167	201	239	287	324	374
64					142	174	210	250	301	339	391
66					149	182	219	260	314	354	407
68					155	190	228	271	328	369	424
70					162	198	237	282	342	384	441
72								293	356	400	458
74								305	371	415	476
76								316	385	431	493
78								328	400	446	511
80								339	414	462	528

Tons of dry matter
x
(100 ÷ % dry matter)
=
tons actual silage

Hay crop silage and/or corn silage — **Vertical silo**

EXAMPLE: 30' settled silage (33% dry matter) in 20' diameter silo.
From table – 59 tons dry matter x 3.3.

100 ÷ 33% dry matter = 195 tons silage.

Trench silo

1. Calculate cubic feet per running foot: silage depth x average width of trench.
2. Calculate tons per running foot:
   (cubic feet x 35 lbs average weight ÷ cubic feet) ÷ 2,000 lbs/ton.
3. Calculate total capacity: tons/running foot x length of trench.

EXAMPLE: Trench silo 8' deep, 8' wide at bottom, 10' wide at top, 20' long.

1. Average width = (8' + 10') ÷ 2 = 9.
2. Cubic feet per running foot = 8' x 9' = 72'.
3. Tons per running foot = (72' x 35 lbs = 2,520 lbs) ÷ 2,000 = 1.26 tons.
4. 1.26 tons per running foot x 20' = 25.2 tons.

Table 24. Influence of stage of maturity on the nutritive content and yield of TDN of small-grain silage.

Stage	Dry-Matter Basis		
	DP	TDN	TDN
	(%)	(%)	(1 lb/acre)
1% flowering	9	66	—
20% flowering	8	60	4,800
Milk	7	50	4,700
Dough	6	55	4,900

Source: Dairy Reference Manual, College of Agriculture, Pennsylvania State University.

Table 25. Influence of stage of maturity on nutritive content of first-cutting hay crop forage.

Approximate Dates[a]		Stage	Dry Matter Basis		
			TDN	CP, Grass	CP, Legume
Grasses	Legumes		(%)		
May 15	May 15	Vegetative	70	18.4	23.9
May 30	May 30	Early Head	63	14.5	19.5
June 15	June 15	Full Bloom	56	11.0	14.7
June 30	June 30	Mature	49	7.7	10.6

[a] For central Pennsylvania. Add or subtract 1 week for northern and southern areas.

Source: Dairy Reference Manual, College of Agriculture, Pennsylvania State University.

Table 26. Maximum exposed surface of horizontal silos.

Feeding Rate	Surface Area
(lb/animal)	(ft^2/animal)
20	2
30	3
40	4
50	5
60	6
70	7
80	8

Values based on removing a 4" slice/day to reduce spoilage.

Table 27. Silage removal.*

Silage Type	Silage Removed (inches/day)	
	Weather	
	Cold	Hot
Whole corn	2	4-6
Alfalfa-brome	2	3-4
Chopped ear corn	2	2
Cracked shell corn	4	4

* Amount of silage removal to reduce spoilage.

Table 28. Bunker silo removal rate.

■ **Determining Removal Rate**

$$\text{Removal rate, inches/day} = \frac{(\text{haycrop silage DM intake per cow, lbs/day}) \times (\text{number of cows})}{(\text{silo width, ft}) \times (\text{silage vertical depth, ft})}$$

Example: **50 cows** each eat **10 lbs** of alfalfa silage DM per day and are fed from a **20 ft** wide, **12 ft** deep bunker silo.

$$\text{Removal rate} = \frac{(10 \text{ lbs/day}) \times (50 \text{ cows})}{(20 \text{ ft}) \times (12 \text{ ft})} = 2.1 \text{ inches/day}$$

■ **Determining Removal Rate From Bunker Silos, Corn Silage**

$$\text{Removal rate, inches/day} = \frac{(\text{corn silage DM intake per cow, lbs/day}) \times (\text{number of cows})}{(\text{silo width, ft}) \times (\text{silage vertical depth, ft}) \times 1.475}$$

Source: NRAES-5, 1990.

Table 29. Hay equivalent intake by dairy cows per animal unit.

	Time Period (days)				
Daily Hay-Equivalent Intake[a]	1	240	270	300	365
(lb/cwt bodyweight)	(lb)	(ton)	(ton)	(ton)	(ton)
2.0	20	2.39	2.70	3.00	3.64
2.2[b]	22	2.63	2.96	3.30	4.00
2.4	24	2.87	3.23	3.59	4.37
2.6	26	3.12	3.50	3.90	4.73

Note: One animal unit equals 1,000 lb live body weight. Multiply values above by animal-unit factor for the breed involved.

[a] Assumes 90% dry matter content for hay. Multiply by 0.9 to obtain forage dry-matter needs at feeding, estimating silo capacities, etc.

[b] Average hay equivalent intake at usual forage-feeding rates.

Source: Dairy Reference Manual, College of Agriculture, Pennsylvania State University, University Park, Penn.

Table 30. Yield conversions.

Grain	Bushels/Acre to Kilograms/Hectare	Kg/Ha to Bushels/Acre
	Multiply by	Multiply by
Barley	53.81	0.0186
Corn	62.78	0.0159
Flaxseed	62.78	0.0159
Oats	35.87	0.0279
Rapeseed	56.05	0.0178
Rye	62.78	0.0159
Soybeans	67.26	0.0149
Wheat	67.26	0.0149

Table 31. Conversion of bushel and hundredweight prices.*

Column A – Feed	Column B – lb/bushel	Column C – bushels/cwt
Barley	48	2.08
Buckwheat	48	2.08
Corn, shelled	56	1.79
Corn, ear		
Single bushel	35	2.86
Double bushel	70	1.43
Oats	32	3.12
Potatoes	60	1.67
Rye	56	1.79
Soybeans	60	1.67
Wheat	60	1.67

* To convert price per bushel to price per cwt, multiply price per bushel by the factor in Column C.

Example:
oats at $0.80 per bushel = $0.80 x 3.12 = $2.50.

To convert price per cwt to price per bushel, multiply price per cwt by pounds per bushel as a percent.

Example:
oats at $2.50 per cwt = $2.50 x .32 = $0.80 per bushel.

Source: Dairy Reference Manual, College of Agriculture, Pennsylvania State University, University Park, Pa.

Table 32. Conversion factors, weights and measures.

Table continues on page 22.

1 pound	=	453.6 grams = 0.4536 kg = 16 ounces
1 ounce	=	28.35 grams
1 killogram	=	1,000 grams = 2.2046 pounds
1 gram	=	1,000 mg
1 mg	=	1,000 µg = 0.001 gram
1 µg	=	0.001 mg = 0.000001 gram
1 µg per gram or 1 mg per kg	=	ppm

Measure of Length (Linear Measure)

4 inches	=	1 hand
9 inches	=	1 span
12 inches	=	1 foot
3 feet	=	1 yard
6 feet	=	1 fathom
5½ yards or 16½ feet	=	1 rod
40 poles	=	1 furlong
8 furlongs	=	1 mile
5,280 feet or 1,760 yards	=	320 rods = 1 mile
3 miles	=	1 league

Liquid Measure

2 cups	=	1 pint
4 gills	=	1 pint
16 fluid ounces	=	1 pint
2 pints	=	1 quart
4 quarts	=	1 gallon
31½ gallons	=	1 barrel
2 barrels	=	1 hogshead
1 gallon	=	231 cubic inches
1 cubic foot	=	7.48 gallons
1 teaspoon	=	0.17 fluid ounces (1/6 ounce)
3 teaspoons (level)	=	1 tablespoon (½ ounce)
2 tablespoons	=	1 fluid ounce
1 cup (liquid)	=	29.57 cubic centimeters
1 teaspoon	=	5 to 6 cubic centimeters
1 tablespoon	=	15 to 16 cubic centimeters
1 fluid ounce	=	29.57 cubic centimeters
1 U.S. fluid ounce	=	29,573 milliliters
1 U.S. liquid quart	=	0.946 liter
1 U.S. dry quart	=	1.101 liters
1 U.S. gallon	=	3.785 liters
1 U.S. bushel	=	0.3524 hectoliters
1 cubic inch	=	16.4 cubic centimeters
1 liter	=	1,000 milliliters or 1,000 cubic centimeters
1 cubic inch	=	16.4 cubic centimeters
1 liter	=	1,000 milliliters or 1,000 cubic centimeters
1 cubic foot water	=	7.48 gallons or 62½ pounds
231 cubic inches	=	1 gallon
1 millimeter	=	0.034 U.S. fluid ounce
1 liter	=	1.057 U.S. liquid quart
1 liter	=	0.908 U.S. dry quart
1 liter	=	0.264 U.S. gallon
1 hectoliter	=	2.838 U.S. bushels
1 cubic centimeter	=	0.061 cubic inch

Cubic Measure (Volume)

1,728 cubic inches	=	1 cubic foot
27 cubic feet	=	1 cubic yard
2,150.42 cubic inches	=	1 standard bushel
231 cubic inches	=	1 standard gallon (liquid)
1 cubic foot	=	7.48 gallons
1 cubic foot	=	4/5 of bushel
128 cubic feet	=	1 cord (wood)
7.48 gallons	=	1 cubic foot
1 bushel	=	1.25 cubic feet
1 grain	=	0.065 gram
1 apothecaries' scruple	=	1.296 grams
1 avoirdupois ounce	=	28.350 grams
1 troy ounce	=	31.103 grams
1 avoirdupois pound	=	0.454 kilogram
1 troy pound	=	0.373 kilogram
1 gram	=	15.432 kilograms
1 gram	=	0.772 apothecaries' scruple
1 gram	=	0.035 avoirdupois ounce
1 gram	=	0.032 troy ounce
1 kilogram	=	2.205 avoirdupois pounds
1 kilogram	=	2.679 troy pounds

Surveyor's Measure

7.92 inches	=	1 link
25 links	=	1 rod
4 rods	=	1 chain
10 square chains	=	160 square rods = 1 acre
640 acres	=	1 square mile
80 chains	=	1 mile
1 Gunthers chain	=	66 feet

Dry Measure

2 pints	=	1 quart
8 quarts	=	1 peck
4 pecks	=	1 bushel
36 bushels	=	1 chaldron

Apothecaries' Weight

20 grains	=	1 scruple
3 scruples	=	1 dram
8 drams	=	1 ounce
12 ounces	=	1 pound
27 - 11/32 grains	=	1 dram
16 drams	=	1 ounce
2,000 pounds	=	1 ton (short)
2,240 pounds	=	1 ton (long)

Metric Length

1 inch	=	2.54 centimeters
1 foot	=	0.305 meters
1 yard	=	0.914 meter
1 mile	=	1.609 kilometers
1 fathom	=	6 feet
1 knot	=	6,086 feet
3 knots	=	1 league
1 centimeter	=	0.394 inch
1 meter	=	3.281 feet
1 meter	=	1.094 yards
1 grain	=	0.065 gram
1 kilometer	=	0.621 mile

Troy Weight

24 grains	=	1 pennyweight
20 pennyweight	=	1 ounce
12 ounces	=	1 pound

Measure of Surface (Area)

144 square inches	=	1 square foot
9 square feet	=	1 square yard
30¼ square yards	=	1 square rod
160 rods	=	1 acre
43,560 square feet	=	1 acre
640 square acres	=	1 square mile
36 square miles	=	1 township

Miscellaneous Equivalents

9 inches	=	1 span
6 feet	=	1 fathom
6,080 feet	=	1 nautical mile
1 board foot	=	144 cubic inches
1 cylindrical foot	=	5 7/8 gallons
1 cubic foot	=	0.8 bushel
12 dozen	=	1 gross
baker's dozen	=	13 count
1 gallon water	=	about 8.3 pounds
1 gallon milk	=	about 8.6 pounds
1 gallon cream	=	about 8.4 pounds
46½ quarts of milk	=	100 pounds
1 cubic foot water (contains 7½ gallons)	=	62½ pounds
1 gallon kerosene	=	6½ pounds
1 barrel cement	=	3.8 cubic feet
1 barrel oil	=	42 gallons
1 standard bale cotton	=	480 pounds
1 keg nails	=	100 pounds
4 inches	=	1 hand in measuring horses
1 furlong	=	660 feet

Table 33. Approximate conversions from metric to English measures and vice versa.

Table continues on page 24.

Symbol	When You Know	Action	To Find LENGTH	Symbol
mm	millimeter	X 0.04	inch	in.
cm	centimeters	X 0.394	inch	in.
m	meter	X 3.3	feet	ft.
m	meter	X 1.094	yard	yd.
km	kilometer	X 0.621	mile	mi.
in.	inch	X 2.54	centimeter	cm
ft.	feet	X 30	centimeter	cm
yd.	yard	X 0.914	meter	m
mi.	mile	X 1.609	kilometer	km

Symbol	When You Know	Action	To Find AREA	Symbol
cm^2	square centimeter	X 0.16	square inch	$in.^2$
m^2	square meter	X 1.2	square yard	$yd.^2$
km^2	square kilometer	X 0.386	square mile	mi.
ha	hectare (10,000 m^2)	X 2.471	acre	ac.
$in.^2$	square inch	X 6.5	square centimeter	cm^2
$ft.^2$	square feet	X 0.09	square meter	m^2
$yd.^2$	square yard	X 0.8	square meter	m^2
$mi.^2$	square mile	X 2.59	square kilometer	km^2
km^2	square kilometer	X 247.1	acre	ac.
ac.	acre	X 0.00405	square kilometer	km^2
ac.	acre	X 0.405	hectare	ha
	diameter circle	X 3.1416	circumference circle	
	diameter circle	X 0.8862	side of equal square	
	diameter circle squared	X 0.7854	area of circle	
	diameter $sphere^2$	X 3.1416	area of sphere	
	diameter $sphere^3$	X 0.5236	volume of sphere	
	U.S. gallons	X 0.8327	Imperial gallons (British)	
	U.S. gallons	X 0.1337	cubic feet	
	U.S. gallons	X 8.330	pounds of water (20EC)	
	cubic feet	X 62.427	pounds of water (4EC)	
	inches of mercury (0EC)	X 0.4912	pounds per sq. in.	
	knots	X 1.1516	miles per hour	

Symbol	When You Know	Action	To Find MASS (weight)	Symbol
g	gram	X 0.035	ounce	oz.
q	quintal	X 220.5	pound	lb.
lb.	pound	X 0.00454	quintal	q
kg	kilogram	X 2.205	pounds	lb.
t	tonnes/ton (1,000 kg) (metric)	X 1.102	short ton (2,000 lbs) (English)	t.
oz.	ounce	X 28	gram	g
lb.	pound	X 0.454	kilogram	kg
t	ton (2,000 pounds) (English)	X 0.9072	tonne/ton (1,000 kg) (metric)	t
	ton (metric)/hectare	X 0.446	ton (English)/acre	
	ton (English)/acre	X 2.242	ton (metric)/acre	
kg/ha	kilograms/hectare	X 0.892	pounds/acre	lbs/ac
lbs/ac	pounds/acre	X 1.121	kilograms/hectare	kg/ha
	quintal/hectare	X 0.892	hundredweight/acre	cwt/ac
cwt/ac	hundredweight/acre	X 1.121	quintal/hectare	

Symbol	When You Know	Action	To Find VOLUME	Symbol
ml	milliliter	X 0.03	fluid ounce	fl. oz.
l	liter	X 2.1	pint	pt.
l	liter	X 1.057	quart	qt.

Symbol	When You Know	Action	To Find VOLUME	Symbol
l	liter	X 0.26	gallon	gal.
hl	hectoliter	X 3.532	cubic foot	ft^3
ft^3	cubic foot	X 0.2832	hectoliter	hl
hl	hectoliter	X 2.838	bushel	bu
bu	bushel	X 0.352	hectoliter	hl
m^3	cubic meter	X 35	cubic feet	$ft.^3$
m^3	cubic meter	X 1.3	cubic feet	$ft.^3$
m^3	cubic meter	X 0.00973	acre - inch	
	acre inch	X 102.8	cubic meter	m^3
tsp.	teaspoon	X 5	milliliter	ml
Tbsp.	tablespoon	X 15	milliliter	ml
fl. oz.	fluid ounce	X 30	milliliter	ml
c.	cup	X 0.24	liter	l
pt.	pint	X 0.47	liter	l
qt.	quart	X 0.946	liter	l
gal.	gallon	X 3.8	liter	l
$ft.^3$	cubic feet	X 0.03	cubic meter	m^2
$yd.^3$	cubic yard	X 0.76	cubic meter	m^3

Symbol	When You Know	Action	To Find TEMPERATURE	Symbol
°C	Celsius	X 1.80, + 32	Fahrenheit	°F
°F	Fahrenheit	X 0.555	(F - 32)	Celsius °C
	absolute zero, degrees Celsius	X 9/5, then + 32	absolute zero, degrees Fahrenheit	
	absolute zero, degrees Fahrenheit	– 32, then X 5/9	absolute zero, degrees Celsius	
	degrees Celsius	+ 273.16	degrees Kelvin	
	degrees Fahrenheit	+ 459.69	degrees Rankine	

Symbol	When You Know	Action	To Find LIGHT	Symbol
	lux	X 0.0929	foot-candle	ft-c
ft-c	foot-candle	X 10.764	lux	

Symbol	When You Know	Action	To Find PRESSURE	Symbol
kg/cm^2	kilograms/square centimeter	X 14.22	pounds/square inch	psi
psi	pounds/square inch	X 0.0703	kilograms/square centimeter	kg/cm^2
	bar	X 14.50	pounds/square inch	psi
psi	pounds/square inch	X 0.0703	kilograms/square centimeter	kg/cm^2
	bar	X 0.9869	atmosphere (English)	atm
atm	atmosphere (English)	X 1.013	bar	
kg/cm^2	kilograms/square centimeter	X 0.9678	atmosphere (metric)	atm
	atmosphere (metric)	X 1.033	kilograms/square centimeter	kg/cm^2
atm	atmosphere (English)	X 14.70	pounds/square inch	psi
psi	pounds/square inch	X 0.06805	atmosphere	atm

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For more information on this and other topics, see www.ag.ndsu.edu.

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