Chapter 3. **Stacked Roundwood, Preservative-Treated Products, and Construction Logs**

Chapter 3. **Stacked Roundwood, Preservative-Treated Products, and Construction Logs**

Stacked Roundwood

Fuelwood and pulpwood are often sold in units represented by stacked piles with the roundwood split or unsplit, and with or without bark. The two basic volumetric units are the cord and the stere, which are defined below. In many places these unit measurements are being replaced by the weight scaling methods discussed in Chapter 2 for logs.

Cord Measure

Standard Rough Cord. A standard rough cord occupies 128 gross cubic feet (3.62 cubic meters) usually comprising 4 foot long split or unsplit roundwood, generally with bark, stacked in a pile 4 feet high and 8 feet long. In some situations, stacks of longer pieces (such as 8 foot lengths) are estimated in terms of standard rough cords.

Long Cord. A long cord is made up of 5 foot long pieces in a stack 4 feet high and 8 feet long, occupying 160 gross cubic feet (4.53 cubic meters). The long cord is 1.25 times greater than the standard cord and is often used in the southern United States.

The Unit. The long cord is sometimes referred to as a unit. In some cases, this term refers to a cord comprising pieces 5' 3" long in a 4 foot high by 8 foot stack occupying 168 gross cubic feet (4.76 cubic meters).

Face Cord. This term is sometimes used for firewood and refers to stove-length pieces in a 4 foot high by 8 foot stack. With 16 inch long pieces, a face cord occupies one-third the gross space (42.3 cubic feet) of a standard rough cord. With 24 inch long pieces, it occupies half the gross space (64 cubic feet) of a standard rough cord.

Volume of Solid Wood in a Cord. These cord measures are not a very accurate indication of the actual solid wood volume, because the amount of air space occupied varies with the diameter, length, bark thickness, and condition of the pieces. Condition refers to crookedness as well as surface roughness caused by limbs.

than 12 inches (USFS 1935). The range for hardwoods was from 85 to 98 cubic feet, and use of 8 foot rather than 4 foot bolts reduced these figures by 2 to 3 cubic feet. When bolts were crooked, rough, and knotty, volume per cord was reduced by about 20 cubic feet.

In practice, an average conversion factor of 85 cubic feet (2.41 cubic meters) of wood per standard rough cord is often assumed. The USFS assessment assumes 79.2 cubic feet per cord (Appendix 2). Due to the factors affecting actual volume, the range around this average can easily be plus or minus 20 cubic feet. Table 3-2 shows the effect of species (bark thickness) and diameter on solid content of a standard rough cord (Worthington and Twerdal 1950). Cubic meter equivalents have been added by the author. The 85 cubic feet per cord factor is reached at 11 inches in hemlock and 15 inches in Douglas-fir. If bolts in a cord have been debarked, the values under the total column give a reasonable approximation of the solid wood content.

Stere Measure

Countries on the metric system use the stere as the standard measure for stacked roundwood. A stere is a space that is one meter on a side, hence one gross cubic meter (35.315 cubic feet, 0.276 standard rough cord). The term stere is used to differentiate this gross space from a solid cubic meter of wood. In some places the term *loose cubic meter* is used rather than the term stere.

A rule of thumb in Europe is that the solid wood content of a stere of pulpwood is 0.65 cubic meters (23.0 cubic feet) for a rough (with bark) stere and 0.75 cubic meters (26.5 cubic feet) for a debarked stere (Jennings 1965). Table 3-1 shows somewhat different conversions and gives an indication of the effect of species and length.

Table 3-1. *Solid content of barky standard cord and stere.*

Kind of bolt	Midbolt diameter:	15 cm 6 in		15 cm to 30 cm 6 in to 12 in		30 cm >12 in	
	Bolt length:	1.2 m 4 ft	2.4 m 8 ft	1.2 m 4 ft	2.4 m 8 ft	1.2 m 4 ft	2.4 m 8 ft
SOFTWOODS							
Straight							
Smooth	(m^3/stere)	0.70	0.69	0.74	0.73	0.78	0.77
	(ft^3/cord)	90	88	95	93	100	98
Slightly rough and knotty	(m^3/stere)	0.66	0.63	0.71	0.69	0.75	0.73
	(ft^3/cord)	84	80	91	88	96	94
Not Straight							
Slightly crooked and rough	(m^3/stere)	0.63	0.59	0.69	0.66	0.73	0.71
	(ft^3/cord)	80	76	88	84	93	91
Crooked, rough, and knotty	(m^3/stere)	0.55	0.51	0.62	0.59	0.65	0.63
	(ft^3/cord)	70	65	79	75	83	80
HARDWOODS							
Straight							
Smooth	(m^3/stere)	0.66	0.64	0.71	0.69	0.77	0.74
	(ft^3/cord)	85	82	91	88	98	95
Slightly rough and knotty	(m^3/stere)	0.61	0.57	0.66	0.64	0.72	0.70
	(ft^3/cord)	78	73	85	82	92	90
Not Straight							
Slightly crooked and rough	(m^3/stere)	0.59	0.55	0.64	0.62	0.70	0.67
	(ft^3/cord)	75	70	82	79	89	86
Crooked, rough, and knotty	(m^3/stere)	0.52	0.47	0.59	0.55	0.61	0.59
	(ft^3/cord)	67	60	75	70	78	75

Source: Adapted from USFS (1935) by Flann (1962). Original data in Imperial units; metric values added by the author.

Conversions Between Cords and Steres

Table 3-3 summarizes conversions using the 85 ft^3/cord and European solid contents of steres. FAO, in its *Yearbook of Forest Products*, uses the gross cubic volumes (128 ft^3/cord and 1 m^3/stere).

Cord and Stere Weight

Table 3-2 also presents the green weight per cord for Douglas-fir and hemlock. In addition to factors affecting the solid volume of a cord, weight depends on moisture content and species specific gravity. Many organizations have shifted to weight scaling (see Chapter 2, pp. 34-35) to develop local weight factors to account for species and seasonal effects. Since many purchasers are not interested in bark, either the weight factors or the price paid may be adjusted for it.

Chapter 1 (p. 10) presents procedures for estimating the weight of a cord or stere based on the solid wood volume, species specific gravity, and moisture content. The example also illustrates how bark weight can be included or excluded.

Preservative-Treated Products

Preservative treatments are often given to wood to enhance durability, fire retardant ability, and

3

Table 3-2. *Solid volume and weight of stacked cords of 8 foot pulpwood in western Washington.*

Average midbolt diameter inside bark	Average solid cubic volume						Average green weight
	Total		Solid wood		Bark		
(inches)	(ft^3)	(m^3)	(ft^3)	(m^3)	(ft^3)	(m^3)	(lb)
			Douglas-fir (with bark)				
8	92	2.60	81	2.29	11	0.31	4,350
9	92	2.60	81	2.29	11	0.31	4,350
10	92	2.60	82	2.32	10	0.28	4,450
11	92	2.60	82	2.32	10	0.28	4,450
12	92	2.60	82	2.32	10	0.28	4,450
13	93	2.63	83	2.35	10	0.28	4,500
14	94	2.66	84	2.38	10	0.28	4,550
15	95	2.69	85	2.41	10	0.28	4,600
16	96	2.72	86	2.44	10	0.28	4,650
17	99	2.80	88	2.49	11	0.31	4,750
18	100	2.83	89	2.52	11	0.31	4,800
19	101	2.86	90	2.55	11	0.31	4,850
20	103	2.92	91	2.58	12	0.34	5,000
			Hemlock (with bark)				
8	91	2.58	81	2.29	10	0.28	4,850
9	92	2.60	82	2.32	10	0.28	4,900
10	94	2.66	84	2.38	10	0.28	5,050
11	95	2.69	85	2.41	10	0.28	5,100
12	96	2.72	86	2.44	10	0.28	5,150
13	97	2.75	87	2.46	10	0.28	5,200
14	99	2.80	88	2.49	11	0.31	5,300
15	100	2.83	89	2.52	11	0.31	5,350
16	100	2.83	89	2.52	11	0.31	5,350

Source: Worthington and Twerdal (1950).
Note: Values may not sum due to rounding.

Table 3-3. *Cordwood conversion factors.*

	ft^3 SWE	m^3 SWE	Standard cord, rough	Stere, rough	Stere, debarked
Standard cord, rough	85.0	2.41	1	3.70	3.21
Stere, rough	23.0	0.65	0.27	1	0.87
Stere, debarked	26.5	0.75	0.31	1.15	1

Source: Calculated by the author.

SWE = solid wood equivalent.

so forth. The major categories are round products such as poles and pilings and sawn products such as railroad ties and lumber treated for decking, sills, and similar applications. The reader should obtain a current copy of the American Wood-Preservers' Association Standards, which has information on various preservatives and retention rates in different applications. Poles and pilings are round structural members which require processing that includes debarking, peeling to desired shape, seasoning, and usually treatment with preservatives. They are relatively straight, free of large knots, and have growth rate (rings per inch) requirements for wood close to their surface. Finished products are commonly sold by the piece.

Pole Measurement and Specifications

Dry, Finished Poles. Poles are placed in classes depending on minimum circumference at the top, minimum circumference 6 feet from the bottom (butt), and species. Table 3-4 presents specifications for species groups that include Douglas-fir and western redcedar; specifications for other species groups are available in the ANSI standard for poles (ANSI 1992).

Classification of poles is based on load-bearing capacity, and the system is defined so a pole of given length and class has essentially the same load-bearing capacity regardless of species. This is why, for example, a 50 foot, class 1 Douglas-fir pole has a smaller circumference 6 feet from the butt than western redcedar (45.0 versus 49.5 inches). Douglas-fir is a stronger species and has less taper.

Since poles are measured for classification while in the green condition, some shrinkage (about 2%) will occur due to seasoning by the manufacturer or while in service. This shrinkage is taken into account when classifying poles using dry meas-urements.

Poles used for power transmission lines are from 55 to 125 feet long. Power distribution poles range from 30 to 50 feet. Those used for pole buildings are generally shorter than 30 feet.

Barky Pole Stock. Pole manufacturers translate the finished pole specifications into tables that can be used by foresters and loggers in assessing the suitability of a tree for pole manufacture. Table 3-5 is an example for Douglas-fir. Each manufacturer has its own pole stock tables that reflect its experience with the bark thickness and taper of a species obtained from a given region.

For example, Table 3-4 shows that a 50 foot, class 1 pole must have a minimum top circumference of 27 inches and a minimum circumference 6 feet from the butt of 45 inches. Table 3-5 shows that this has been translated into a 9 inch minimum top diameter inside bark and a 53 inch minimum outside bark circumference 6 feet from the butt.

Pole Volume

AWPA Methods. Two methods given in Standard F3 of the American Wood-Preservers' Association (AWPA 1992) for calculating cubic foot volume of individual poles are:

$$V = 3\,L\,(C_m / \pi)^2\; 0.001818 \qquad (1)$$

$$V = 0.001818\,L\,(D^2 + d^2 + Dd)\,f \qquad (2)$$

where

V	=	volume (ft^3)
π	=	3.14159
C_m	=	midlength circumference, in inches
D, d	=	butt and top diameters, in inches
L	=	length, in feet
f	=	correction = 0.82 oak piles = 0.93 southern pine piles = 0.95 southern pine, red pine poles = 1.0 otherwise

Formula 1 is the AWPA official method except for Douglas-fir, for which either method can be used. AWPA Standard F3 contains volume tables based on both formulas. Table 3-6 presents cubic feet per lineal foot factors based on Formula 2 when the correction f in the formula is set to 1.0. See Example 1. (In examples and AWPA tables, the effect of bark thickness is ignored.)

Manufacturers' Volume Tables by Pole Class. Based on the average pole circumferences in each class and length, manufacturers publish their own tables of pole volumes. Table 3-7 presents cubic foot volume of *average* poles for Douglas-fir and western redcedar. Differences between manufacturers' tables are small, reflecting minor differences in average circumferences within a class, and practices of rounding numeric values.

Table 3-4. *Specifications for finished poles.*

A. Dimensions of Douglas-fir (West-side and East-side) and southern pine poles																
	Class:	H-6	H-5	H-4	H-3	H-2	H-1	1	2	3	4	5	6	7	9	10
	Minimum circumference at top (Inches):	39	37	35	33	31	29	27	25	23	21	19	17	15	15	12
Length of pole (ft)	Groundline distance from butt[a] (ft)	Minimum circumference at 6 feet from butt (inches)														
20	4	-	-	-	-	-	-	31.0	29.0	27.0	27.0	23.0	**21.0**	**19.5**	**17.5**	**14.0**
25	5	-	-	-	-	-	-	33.5	31.5	29.5	27.5	25.5	**23.0**	**21.5**	**19.5**	**15.0**
30	5.5	-	-	-	-	-	-	36.5	**34.0**	**32.0**	**29.5**	**27.5**	**25.0**	**23.5**	**20.5**	-
35	6	-	-	-	-	**43.5**	**41.5**	39.0	**36.5**	**34.0**	**31.5**	**29.0**	**27.0**	**25.0**	-	-
40	6	-	-	**51.0**	**48.5**	**46.0**	**43.5**	**41.0**	**38.5**	**36.0**	**33.5**	**31.0**	**28.5**	-	-	-
45	6.5	**58.5**	**56.0**	**53.5**	**51.0**	**48.5**	**45.5**	**43.0**	**40.5**	**37.5**	**35.0**	**32.5**	30.0	-	-	-
50	7	**61.0**	**58.5**	**55.5**	**53.0**	**50.5**	**47.5**	**45.0**	**42.0**	**39.0**	36.5	34.0	-	-	-	-
55	7.5	**63.5**	**60.5**	**58.0**	**55.0**	**52.0**	**49.5**	**46.5**	**43.5**	**40.5**	38.0	-	-	-	-	-
60	8	**65.5**	**62.5**	**59.5**	**57.0**	**54.0**	**51.0**	**48.0**	**45.0**	**42.0**	39.0	-	-	-	-	-
65	8.5	**67.5**	**64.5**	**61.5**	**58.5**	**55.5**	**52.5**	**49.5**	**46.5**	**43.5**	40.5	-	-	-	-	-
70	9	**69.0**	**66.5**	**63.5**	**60.5**	**57.0**	**54.0**	**51.0**	**48.0**	**45.0**	41.5	-	-	-	-	-
75	9.5	**71.0**	**68.0**	**65.0**	**62.0**	**59.0**	**55.5**	**52.5**	**49.0**	**46.0**	-	-	-	-	-	-
80	10	**72.5**	**69.5**	**66.5**	**63.5**	**60.0**	**57.0**	**54.0**	**50.5**	47.0	-	-	-	-	-	-
85	10.5	**74.5**	**71.5**	**68.0**	**65.0**	**61.5**	**58.5**	**55.0**	**51.5**	48.0	-	-	-	-	-	-
90	11	**76.0**	**73.0**	**69.5**	**66.5**	**63.0**	**59.5**	**56.0**	**53.0**	49.0	-	-	-	-	-	-
95	11	**77.5**	**74.5**	**71.0**	**67.5**	**64.5**	**61.0**	**57.0**	**54.0**	-	-	-	-	-	-	-
100	11	**79.0**	**76.0**	**72.5**	**69.0**	**65.5**	**62.0**	**58.5**	**55.0**	-	-	-	-	-	-	-
105	12	**80.5**	**77.0**	**74.0**	**70.5**	**67.0**	**63.0**	**59.5**	**56.0**	-	-	-	-	-	-	-
110	12	**82.0**	**78.5**	**75.0**	**71.5**	**68.0**	**64.5**	**60.5**	**57.0**	-	-	-	-	-	-	-
115	12	**83.5**	**80.0**	**76.5**	**72.5**	**69.0**	**65.5**	**61.5**	**58.0**	-	-	-	-	-	-	-
120	12	**85.0**	**81.0**	**77.5**	**74.0**	**70.0**	**66.5**	**62.5**	**59.0**	-	-	-	-	-	-	-
125	12	**86.0**	**82.5**	**78.5**	**75.0**	**71.0**	**67.5**	**63.5**	**59.5**	-	-	-	-	-	-	-

☐ [a]The figures in this column are intended for use only when a definition of groundline is necessary in order to apply requirements related to scars, straightness, etc.

Note: Classes and lengths for which circumferences at 6 feet from the butt are listed in boldface are the preferred standard sizes. Those shown in lightface are included for engineering purposes only.

B. Dimensions of western redcedar and ponderosa pine poles*

Class:		H-6	H-5	H-4	H-3	H-2	H-1	1	2	3	4	5	6	7	9	10
Minimum circumference at top (Inches):		39	37	35	33	31	29	27	25	23	21	19	17	15	15	12
Length of pole (ft)	Groundline distance from butt[a] (ft)	Minimum circumference at 6 feet from butt (inches)														
20	4	-	-	-	-	-	-	33.5	**31.5**	29.5	27.0	25.0	**23.0**	**21.5**	**18.5**	**15.0**
25	5	-	-	-	-	-	-	37.0	**34.5**	32.5	30.0	28.0	**25.5**	**24.0**	**20.5**	**16.5**
30	5.5	-	-	-	-	-	-	40.0	**37.5**	**35.0**	**32.5**	**30.0**	**28.0**	**26.0**	**22.0**	-
35	6	-	-	-	-	**48.0**	**45.5**	42.5	**40.0**	**37.5**	**34.5**	**32.0**	**30.0**	**27.5**	-	-
40	6	-	-	**56.5**	**53.5**	**51.0**	**48.0**	**45.0**	**42.5**	**39.5**	**36.5**	**34.0**	**31.5**	-	-	-
45	6.5	**64.5**	**62.0**	**59.0**	**56.0**	**53.5**	**50.5**	**47.5**	**44.5**	**41.5**	**38.5**	**36.0**	33.0	-	-	-
50	7	**67.0**	**64.5**	**61.5**	**58.5**	**55.5**	**52.5**	**49.5**	**46.5**	**43.5**	40.0	37.5	-	-	-	-
55	7.5	**70.0**	**67.0**	**64.0**	**61.0**	**57.5**	**54.5**	**51.5**	**48.5**	**45.0**	42.0	-	-	-	-	-
60	8	**72.0**	**69.0**	**66.0**	**63.0**	**59.5**	**56.5**	**53.5**	**50.0**	**46.5**	43.5	-	-	-	-	-
65	8.5	**74.5**	**71.5**	**68.0**	**65.0**	**61.5**	**58.5**	**55.0**	**51.5**	**48.0**	45.0	-	-	-	-	-
70	9	**76.5**	**73.5**	**70.0**	**67.0**	**63.5**	**60.0**	**56.5**	**53.0**	**49.5**	46.0	-	-	-	-	-
75	9.5	**78.5**	**75.5**	**72.0**	**68.5**	**65.0**	**61.5**	**58.0**	**54.5**	**51.0**	-	-	-	-	-	-
80	10	**80.5**	**77.0**	**74.0**	**70.5**	**67.0**	**63.0**	**59.5**	**56.0**	52.0	-	-	-	-	-	-
85	10.5	**82.5**	**79.0**	**75.5**	**72.0**	**68.5**	**64.5**	**61.0**	**57.0**	53.5	-	-	-	-	-	-
90	11	**84.5**	**81.0**	**77.0**	**73.5**	**70.0**	**66.0**	**62.5**	**58.5**	54.5	-	-	-	-	-	-
95	11	**86.0**	**82.5**	**79.0**	**75.0**	**71.5**	**67.5**	**63.5**	**59.5**	-	-	-	-	-	-	-
100	11	**87.5**	**84.0**	**80.5**	**76.5**	**72.5**	**69.0**	**65.0**	**61.0**	-	-	-	-	-	-	-
105	12	**89.5**	**85.5**	**82.0**	**78.0**	**74.0**	**70.0**	**66.0**	**62.0**	-	-	-	-	-	-	-
110	12	**91.0**	**87.0**	**83.5**	**79.5**	**75.5**	**71.5**	**67.5**	**63.0**	-	-	-	-	-	-	-
115	12	**92.5**	**88.5**	**84.5**	**80.5**	**76.5**	**72.5**	**68.5**	**64.0**	-	-	-	-	-	-	-
120	12	**94.0**	**90.0**	**86.0**	**82.0**	**78.0**	**74.0**	**69.5**	**65.0**	-	-	-	-	-	-	-
125	12	**95.5**	**91.5**	**87.5**	**83.0**	**79.0**	**75.0**	**70.5**	**66.0**	-	-	-	-	-	-	-

☐ [a]The figures in this column are intended for use only when a definition of groundline is necessary in order to apply requirements related to scars, straightness, etc.

Note: Classes and lengths for which circumferences at 6 feet from the butt are listed in boldface are the preferred standard sizes. Those shown in lightface are included for engineering purposes only.

* Dimensions of H-classes are applicable for western redcedar only.

Source: ANSI (1992).

Example 1

Consider a 25 foot, class 1 pole that has a minimum top diameter inside bark (d) of 9 inches and minimum circumference outside bark of 38.5 inches located 6 feet from the butt (C_6). To estimate the volume of a pole having these minimum class 1 dimensions:

Formula 1

First, estimate C_m from the pole taper as follows:

$C_m = [(C_6 - \pi\ d) / (L - 6)]\ L / 2 + \pi\ d = [(38.5 - 3.14159 * 9)$

$/ (25 - 6)]\ 25 / 2 + 3.14159 * 9 = 35.0.$

Then, $V = 3\ L\ (C_m / \pi)^2\ 0.001818 = 3 * 25\ (35.0 /$

$3.14159)^2\ 0.001818 = 16.9\ ft^3.$

The AWPA table has a value of 16.8 ft^3.

Formula 2

First, estimate the butt end diameter (D) from pole taper:

$D = [(C_6 / \pi - d) / (L - 6)]\ L + d = [(38.5 / 3.14159 - 9) /$

$(25 - 6)]\ 25 + 9 = 13$ inches.

Then, $V = 0.001818\ L\ (D^2 + d^2 + Dd) = 0.001818 * 25$

$(132 + 92 + 13 * 9) = 16.7\ ft^3.$

Alternatively, Table 3-6 has a cubic foot/lineal foot factor of 0.667 for a pole with a large end diameter of 13 inches and a small end diameter of 9 inches; multiplying by length yields 16.7 ft^3.

Pole Weights

Factors influencing pole weight are: (1) pole volume; (2) specific gravity of species (Table 1-1); (3) moisture content of pole (MC_{od} of a dry pole is about 25%); and (4) preservative type and retention. The latter three are combined to give the weight density (pounds per cubic foot) of a pole, which, multiplied by pole cubic volume, estimates shipping weight.

Estimating Weight Density (lb/ft^3). In the absence of actual manufacturers' data, weight density of a treated pole can be approximated by methods outlined in Chapter 1. Using Douglas-fir as an example, $SG_g = 0.45$, hence Table 1-2 yields about 35.1 lb/ft^3 at MC_{od} = 25%. Assuming a preservative retention of 12 lb/ft^3 brings the pole weight density to 47.1 lb/ft^3. Multiplying by the volume of a pole in Table 3-7 yields an estimate of its shipping weight. The AWPA standard contains information on retention of various preservatives.

Manufacturers' Pole Shipping Weight Tables. Manufacturers carefully monitor retention rates and shipping weights of their products. For a given pole size and treatment weight, tables of different manufacturers are quite similar. However, weight tables differ substantially according to species and type of treatment. Illustrative weight densities are shown below for treatments of Douglas-fir and western redcedar (source: L. D. McFarland Company) with pentachlorophenol or ACZA.

Douglas-fir

Treatment	Density (lb/ft^3)
0.45 penta	46
0.50 penta	48
0.60 penta	50
0.6 ACZA	58

Western redcedar

Treatment	Density (lb/ft^3)
Full length, 0.80 penta	32
Butt only, 1.00 penta	28
Heavy, full length, 1.25 penta	33

These densities assume a moisture content of 25%.

These factors, multiplied by cubic foot volumes in Table 3-7, result in manufacturers' tables of shipping weights. For example, a 50 foot, class 1 Douglas-fir pole (47.0 ft^3) has a shipping weight of 2,162 pounds when treated with 0.45 penta and 2,350 pounds when treated with 0.60 penta.

Piling Measurement and Specifications

Conceptually, the procedures for piling are very similar to those for poles. However, pilings have a different specification system under ASTM D25-91 (ASTM 1991).

Finished Piles. The original classification for piling listed classes A, B, and C, which gave the minimum circumference at the top and minimum and maximum circumference 3 feet from the butt according to species group and lengths. Table 3-8 presents these specifications. Class C is relatively uncommon in practice.

Table 3-5. *Dimensions of barky Douglas-fir pole stock.*

Class:	1	2	3	4	5	6	7
Minimum diameter inside bark (inches):	9.0	8.5	8.0	7.0	6.5	6.0	5.0
Length of pole (feet)	Minimum circumference 6 feet from butt, outside bark[a] (inches)						
25	39	37	35	33	31	28	27
30	42	40	38	35	33	30	29
35	45	43	40	38	35	33	31
40	48	46	43	40	37		
45	50	48	45	42	39		
50	53	49	45	43			
55	54	51	48				
60	56	53	49				
65	57	54	51				
70	59	56	53				
75	62	58	54				
80	63	59	55				
85	65	61	57				
90	66	62					
95	67	63					
100	69	65					

Source: L. D. McFarland Company, unpublished.

[a]Allows for average bark. Heavy bark may reduce poles one class.

A different, more detailed classification has tables for two species groups: southern yellow pine and Douglas-fir plus other species (ASTM D25-91). For each species group, there is one table that gives minimum top circumferences according to length and required minimum circumference 3 feet from the butt. A second table gives minimum circumferences 3 feet from the butt according to length and required minimum top circumference.

Barky Piling Stock. Manufacturers translate the finished piling specifications into minimum requirements that adjust for bark thickness and taper. These are then used by foresters and loggers in assessing the suitability of a tree for piling. Table 3-9 is an example for Douglas-fir.

Piling Volume

Methods are the same as discussed for poles. Table 3-6 gives cubic foot volume per lineal foot of various sizes of peeled piles. Using AWPA methods and Table 3-10, average cubic foot volumes are obtained for various lengths in each piling class.

Piling Weights

The same procedure discussed for poles can be applied. Treated Douglas-fir piling generally contains 17 pounds of preservative per cubic foot of wood for land-based use and 20 pounds for saltwater use. Moisture content within 2 inches of the surface is about MC_{od} = 25%. Table 3-10 gives average weight factors for clear, peeled, untreated Douglas-fir piles. Adding the preservative retention per cubic foot and multiplying by the cubic foot volume yields an estimate of shipping weight.

Conversion of Pole and Piling Measures to Metric Units

Generally, standard conversions of 35.315 ft^3/m^3 and 2.205 lb/kg (Appendix 1) can be used to convert the pole and pile volume and weights to metric equivalents.

Ties

Railroad crossties are produced from many hardwood and softwood species from logs at least

Diameter of large end (in)	Diameter of small end (inches) 4	4-1/2	5	5-1/2	6	6-1/2	7	7-1/2	8	8-1/2	9	9-1/2	10	10-1/2	11	11-1/2	12	12-1/2	13	13-1/2	14	14-1/2	15
4	0.087																						
4-1/2	0.099	0.110																					
5	0.111	0.123	0.136																				
5-1/2	0.124	0.137	0.150	0.165																			
6	0.138	0.151	0.165	0.180	0.196																		
6-1/2	0.153	0.167	0.181	0.197	0.213	0.230																	
7	0.169	0.183	0.198	0.214	0.231	0.249	0.267																
7-1/2	0.186	0.200	0.216	0.232	0.250	0.268	0.287	0.307															
8	0.204	0.219	0.235	0.251	0.269	0.288	0.307	0.328	0.349														
8-1/2	0.222	0.238	0.254	0.271	0.290	0.309	0.329	0.350	0.371	0.394													
9	0.242	0.258	0.275	0.292	0.311	0.330	0.351	0.372	0.395	0.418	0.442												
9-1/2	0.262	0.279	0.296	0.314	0.333	0.353	0.374	0.396	0.419	0.442	0.467	0.492											
10	0.284	0.300	0.318	0.337	0.356	0.377	0.398	0.420	0.444	0.468	0.493	0.519	0.546										
10-1/2	0.306	0.323	0.341	0.360	0.380	0.401	0.423	0.446	0.470	0.494	0.520	0.546	0.573	0.601									
11	0.329	0.347	0.365	0.385	0.405	0.427	0.449	0.472	0.496	0.521	0.547	0.574	0.602	0.630	0.660								
11-1/2	0.353	0.371	0.390	0.410	0.431	0.453	0.476	0.500	0.524	0.550	0.576	0.603	0.631	0.660	0.690	0.721							
12	0.378	0.397	0.416	0.437	0.458	0.480	0.504	0.528	0.553	0.579	0.605	0.633	0.662	0.691	0.722	0.753	0.785						
12-1/2	0.404	0.423	0.443	0.464	0.486	0.509	0.532	0.559	0.582	0.609	0.636	0.664	0.693	0.723	0.754	0.786	0.819	0.852					
13	0.431	0.450	0.471	0.492	0.515	0.538	0.562	0.587	0.613	0.640	0.667	0.696	0.725	0.756	0.787	0.819	0.853	0.887	0.922				
13-1/2	0.459	0.479	0.500	0.521	0.544	0.568	0.592	0.618	0.644	0.671	0.700	0.729	0.759	0.790	0.821	0.854	0.888	0.922	0.958	0.994			
14	0.487	0.508	0.529	0.551	0.575	0.599	0.624	0.650	0.676	0.704	0.733	0.762	0.793	0.824	0.856	0.890	0.924	0.959	0.994	1.031	1.069		
14-1/2	0.517	0.538	0.560	0.582	0.606	0.630	0.656	0.682	0.710	0.738	0.767	0.797	0.828	0.860	0.892	0.926	0.960	0.996	1.032	1.069	1.108	1.147	
15	0.547	0.569	0.591	0.614	0.638	0.663	0.689	0.716	0.744	0.772	0.802	0.832	0.864	0.896	0.929	0.963	0.998	1.034	1.071	1.109	1.147	1.187	1.227
15-1/2	0.579	0.600	0.623	0.647	0.671	0.697	0.723	0.750	0.779	0.808	0.838	0.869	0.900	0.933	0.967	1.001	1.037	1.073	1.110	1.149	1.188	1.228	1.269
16	0.611	0.633	0.656	0.680	0.705	0.731	0.758	0.786	0.815	0.844	0.875	0.906	0.938	0.971	1.005	1.040	1.076	1.113	1.151	1.189	1.229	1.269	1.311
16-1/2	0.644	0.667	0.690	0.715	0.740	0.767	0.794	0.822	0.851	0.881	0.912	0.944	0.977	1.010	1.045	1.080	1.117	1.154	1.192	1.231	1.271	1.312	1.354
17	0.678	0.701	0.725	0.750	0.776	0.803	0.831	0.860	0.889	0.920	0.951	0.983	1.016	1.050	1.085	1.121	1.158	1.196	1.234	1.274	1.314	1.856	1.398
17-1/2	0.713	0.737	0.761	0.787	0.813	0.840	0.869	0.898	0.928	0.959	0.990	1.023	1.057	1.091	1.127	1.163	1.200	1.239	1.278	1.318	1.359	1.400	1.443
18	0.749	0.773	0.798	0.824	0.851	0.879	0.907	0.937	0.967	0.999	1.031	1.064	1.098	1.133	1.169	1.206	1.244	1.282	1.322	1.362	1.404	1.446	1.489
18-1/2	0.786	0.810	0.836	0.862	0.890	0.918	0.947	0.977	1.008	1.039	1.072	1.106	1.140	1.176	1.212	1.249	1.288	1.327	1.367	1.408	1.449	1.492	1.536
19	0.824	0.849	0.875	0.901	0.929	0.958	0.987	1.018	1.049	1.081	1.114	1.149	1.184	1.219	1.256	1.294	1.333	1.372	1.413	1.454	1.496	1.539	1.584
19-1/2	0.862	0.888	0.914	0.941	0.969	0.999	1.029	1.059	1.091	1.124	1.158	1.192	1.228	1.264	1.301	1.339	1.379	1.419	1.459	1.501	1.544	1.588	1.632
20	0.902	0.928	0.955	0.982	1.011	1.040	1.071	1.102	1.134	1.168	1.202	1.237	1.273	1.309	1.347	1.386	1.425	1.466	1.507	1.549	1.593	1.637	1.682
20-1/2	0.942	0.969	0.996	1.024	1.053	1.083	1.114	1.146	1.179	1.212	1.247	1.282	1.319	1.356	1.394	1.433	1.473	1.514	1.556	1.599	1.642	1.687	1.732
21	0.984	1.010	1.038	1.067	1.096	1.127	1.158	1.190	1.224	1.258	1.293	1.329	1.365	1.403	1.442	1.481	1.522	1.563	1.605	1.649	1.693	1.738	1.784
21-1/2	1.026	1.053	1.081	1.110	1.140	1.171	1.203	1.236	1.269	1.304	1.339	1.376	1.413	1.451	1.490	1.530	1.571	1.613	1.656	1.699	1.744	1.789	1.836
22	1.069	1.097	1.125	1.155	1.185	1.217	1.249	1.282	1.316	1.351	1.387	1.424	1.462	1.500	1.540	1.580	1.622	1.664	1.707	1.751	1.796	1.842	1.889
22-1/2	1.113	1.141	1.170	1.200	1.231	1.263	1.296	1.329	1.364	1.399	1.436	1.473	1.511	1.550	1.590	1.631	1.673	1.716	1.759	1.804	1.849	1.896	1.943
23	1.158	1.187	1.216	1.247	1.278	1.310	1.344	1.378	1.413	1.449	1.485	1.523	1.562	1.601	1.642	1.683	1.725	1.769	1.813	1.858	1.903	1.950	1.998
23-1/2	1.204	1.233	1.263	1.294	1.326	1.359	1.392	1.427	1.462	1.499	1.536	1.574	1.613	1.653	1.694	1.736	1.779	1.822	1.867	1.912	1.958	2.006	2.054
24	1.251	1.280	1.311	1.342	1.374	1.408	1.442	1.477	1.513	1.549	1.587	1.626	1.665	1.706	1.747	1.789	1.833	1.877	1.922	1.968	2.014	2.062	2.111
24-1/2	1.299	1.329	1.359	1.391	1.424	1.458	1.492	1.528	1.564	1.601	1.639	1.679	1.719	1.759	1.801	1.844	1.888	1.932	1.978	2.024	2.071	2.119	2.168
25	1.347	1.378	1.409	1.441	1.474	1.509	1.544	1.579	1.616	1.654	1.693	1.732	1.773	1.814	1.856	1.899	1.943	1.988	2.034	2.081	2.129	2.178	2.227

Source: AWPA (1992).

Note: Based on Formula 2. Multiply the factor for the appropriate diameters by the length and species correction factor (f).

Table 3-7. *Average cubic foot volume of poles by pole class and length.*

Douglas-fir

Length (ft)	Class H6	H5	H4	H3	H2	H1	1	2	3	4	5	6	7	8	9	10
20							12.9	10.3	8.5	7.2	6.0	5.2	4.3	4.8	3.7	2.9
25							18.0	14.8	12.3	10.4	8.9	7.7	6.3	7.1	5.3	4.3
30							23.3	19.7	16.8	14.3	12.0	10.0	8.3	7.3	6.8	
35					37.5	34.5	28.5	24.4	21.0	18.3	15.7	13.5	11.8			
40				53.4	42.5	40.2	34.3	29.5	25.5	22.2	19.3	16.8				
45				63.2	54.9	47.5	40.4	34.8	30.3	26.3	23.2	20.7				
50	98.0	89.0	79.7	73.0	63.2	59.9	47.0	40.3	35.0	30.7						
55	109.8	101.5	90.7	84.5	73.0	63.2	54.4	46.7	40.0	35.2						
60	129.4	117.6	106.3	96.6	86.4	76.8	62.8	53.5	45.7	39.8						
65	145.6	132.5	120.0	108.1	96.9	86.2	73.0	60.8	51.2	44.7						
70	162.5	148.3	134.5	121.5	107.9	96.2	89.0	68.8	57.2	49.7						
75	180.4	164.9	148.4	134.2	120.8	106.8	94.5	77.0	63.8	54.9						
80	197.8	180.8	164.6	147.6	133.1	117.9	106.7	86.2	70.7	60.3						
85	217.5	197.4	179.9	161.7	145.9	129.5	120.0	95.8	78.2							
90	236.3	216.6	195.6	178.1	157.8	140.3	135.7	106.8	86.0							
95	255.9	234.8	212.6	191.7	171.8	153.0	145.5	115.1	92.9							
100	276.0	251.6	230.2	205.7	184.6	164.5	159.1	125.1	100.8							
105	297.1	271.1	246.0	222.3	199.8	178.4	172.2	135.1	108.5							
110	319.0	291.4	264.8	239.5	213.0	190.9	185.8	145.5	116.6							
115	341.7	312.3	281.8	255.2	227.6	203.8	197.3	173.3	138.6							
120	362.3	331.4	301.9	271.1	242.2	217.1	212.2	186.8	149.4							
125	386.3	351.0	320.0	287.6	259.7	240.8	233.9	210.8	168.6							

Western redcedar

Length (ft)	Class H6	H5	H4	H3	H2	H1	1	2	3	4	5	6	7	8	9	10
20							14.2	11.1	9.2	7.7	6.5	5.5	5.2	4.4	3.9	3.1
25							17.3	15.3	13.4	11.5	10.0	8.7	7.4	6.9	6.0	4.0
30							23.1	20.2	17.7	15.2	13.4	11.6	10.0	9.0	7.6	
35					42.4	38.2	29.4	25.1	22.2	19.4	17.1	15.0	13.4			
40			60.4	55.2	51.6	46.8	36.1	31.8	27.4	23.9	21.3	19.0				
45	83.7	79.2	72.5	66.2	60.3	56.7	43.2	37.9	33.1	28.8	25.8					
50	98.5	90.5	83.0	76.0	69.5	65.0	51.1	44.8	38.9	33.9	29.9					
55	114.4	105.6	97.4	89.1	81.4	74.3	59.2	51.8	45.0	39.8						
60	128.4	118.8	109.2	100.2	91.8	83.4	67.6	58.9	51.3	46.0						
65	146.9	135.9	125.5	115.7	102.7	93.6	76.1	66.5	57.9	51.8						
70	162.4	150.5	139.3	128.1	117.6	107.8	85.7	74.4	65.2	58.6						
75	178.5	165.8	153.8	141.8	129.8	119.3	93.9	83.1	72.7							
80	200.8	181.6	168.0	155.2	143.2	127.2	114.7	96.8	83.1							
85	218.5	203.2	183.6	170.0	156.4	139.4	121.9	106.8	91.9							
90	237.6	221.4	199.8	185.4	171.0	152.1	133.9	117.6	101.5							
95	259.4	242.3	225.2	203.3	188.1	166.3	150.5	130.6	112.9							
100	277.0	259.0	234.0	218.0	195.0	185.0	180.0	158.0	138.7							
105	298.2	278.3	253.0	235.2	211.0	205.5	200.0	171.8	152.4							
110	320.1	299.2	271.7	253.0	227.7	222.5	217.7	187.1	166.1							
115	342.7	320.9	292.1	271.4	244.6	241.0	237.7	202.4	179.8							
120	366.0	343.2	312.0	283.2	262.8	259.0	247.4	215.0								

Source: L. D. McFarland Company, unpublished.

Table 3-8. *Circumferences of timber piles: Douglas-fir, hemlock, larch, pine, spruce, or tamarack.*

	Class A			Class B			Class C		
	3 ft from butt		Tip	3 ft from butt		Tip	3 ft from butt		Tip
Length (ft)	Min. (in)	Max. (in)	Min. (in)	Min. (in)	Max. (in)	Min. (in)	Min. (in)	Max. (in)	Min. (in)
< 40	44	57	28	38	63	25	38	63	25
40-50 incl	44	57	28	38	63	22	38	63	19
55-70 incl	44	57	25	41	63	22	38	63	19
75-90 incl	44	63	22	41	63	19	38	63	19
> 90	44	63	19	41	63	16	38	63	16

Source: ASTM D25-58 (ASTM 1958).

Table 3-9. *Dimensions of barky Douglas-fir piling stock.*

	Class A		Class B	
Length (ft)	Min. circumference up 3 ft from butt outside bark (in)	Min. top diameter inside bark (in)	Min. circumference up 3 ft from butt outside bark (in)	Min. top diameter inside bark (in)
Under 40	52	9.5	45.5	8.5
40-52	52	9.5	45.5	7.5
53-72	52	8.5	48.5	7.5
73-92	52	7.5	48.5	6.5
Over 92	52	6.5	48.5	5.5

Source: L. D. McFarland Company, unpublished.

Table 3-10. *Average volume and weight density of Douglas-fir piles.*

	Volume (ft^3)		Density (lb/ft^3), untreated	
Length (ft)	Class A	Class B	Class A	Class B
20	21.4	15.7		
25	25.9	18.9		
30	29.9	21.8		
35	33.7	24.4		
40	37.1	26.7		
45	43.5	31.5		
50	46.7	33.6		
55	49.5	38.7		
60	52.1	40.6	40	34
65	54.5	46.2	40	34
70	56.6	47.7	43	34
75	63.3	53.7	36	31
80	65.2	55.1	40	34
85	72.3	61.5	39	34
90	74.0	62.7	44	34
95	81.7	69.4	40	36
100	83.1	70.5	42	40
105	91.2	84.3	44	41
110	92.4	85.4	46	44
115	108.9	101.1	49	47
120	118.4	102.1	52	50

Source: L. D. McFarland Company, unpublished.

8 feet long with diameters exceeding 7 inches. These logs are sawn into rectangular cross section pieces that are treated with a preservative. There are three basic tie categories, the 8 foot crosstie and the longer switch and bridge ties. According to McCurdy and Case (1989), about two-thirds of all ties produced have a 7 by 10 inch cross section; no other size cross section exceeds 10% of production.

The volume of a tie in cubic feet is simply the product of the cross section area, converted to square feet, times the length in feet. Board foot volume is estimated from the board foot formula for lumber described in Chapter 4. Weight estimates can be made using methods in Chapter 1 and adding the weight of the appropriate preservative (see p. 44).

In their study, McCurdy and Case (1989) use average values of 40 BF for a crosstie and 63 BF for switch and bridge ties (Appendix 2). These translate to about 3.5 ft^3 (0.10 m^3) and 5.25 ft^3 (0.15 m^3) respectively.

Lumber

The procedures described in Chapter 4 should be used in estimating preservative-treated lumber volume. To estimate weight, either obtain shipping weights from the manufacturer or add the retention in lb/ft^3 (see AWPA 1992) to the wood weight density based on the species and moisture content (Chapter 1). Multiply the combined lb/ft^3 by the cubic foot volume of the product.

Construction Logs

Construction logs used in log buildings are often milled into a cross section shape that is uniform along the length of the piece. Volume can be obtained by finding the cross section area in square feet and multiplying by the length. Weight estimation uses methods discussed in Chapter 1.