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DENSITY, FIBER LENGTH, AND YIELDS OF PULP FOR VARIOUS SPECIES OF WOOD

The yield of pulp obtained from a given species of wood is influenced greatly by the kind and severity of the pulping process used. The highest yield, of course, is obtained by strictly mechanical processes that reduce practically all of the wood to a fibrous pulp. The lowest yield is obtained from drastic chemical digestion that gives pulp consisting of nearly pure cellulose fibers. Within these extremes in yield lie pulps with all the gradations in quality needed for use in the many kinds of pulp and paper products that are manufactured.

There are three relatively standard chemical processes for making wood pulp; the sulfite, the sulfate, and the soda processes. The yield of pulp (expressed as a percentage by weight on the moisture-free basis) obtained by digesting wood by one of these chemical processes is dependent to a large extent on the chemical composition of the wood. Since the principal chemical components of the normal sound wood of most species do not vary much in amount, the percentage yield of pulp obtained by a given process does not vary greatly from one species to another. The chemical composition of wood and consequently the yield of chemical pulp generally varies more between softwoods (coniferous woods) and hardwoods (broadleaf woods) as classes than between the individual woods within these classes.

The yield of pulp expressed on a volume basis, such as the pounds of pulp per cubic foot of wood or per cord of wood is affected by the variations in the percentage yield and also in the variations in those structure and growth characteristics of the wood that influence its density and weight per cord.

Because of the many and interacting variations in wood properties and pulping conditions, the yield of pulp obtained from a given wood cannot be stated without qualifications, and a single average value for a species

and process cannot be given. The typical values given in the following tables may, however, be considered to be suitable for general estimating purposes. The percentage yields given in tables 1 and 2 for the three principal chemical pulping processes are those that might be expected in the production of pulp of papermaking grade. Lower yields would be expected in the production of pulp to be used for the manufacture of viscose and other cellulose derivatives, owing to the more severe chemical treatment in their preparation.

The yields of semichemical pulp and groundwood pulp are not included in tables 1 and 2. The yields obtained by these processes are relatively independent of the kind of wood used. The semichemical processes may be operated under a much wider range of conditions than the more standardized chemical processes, and the yields of pulp, as indicated in tables 3 and 4, may vary from about 55 to about 95 percent. In calculating the values given in tables 3 and 4, a yield of 95 percent for groundwood pulp has been used for all species, and the 5 percent loss has been assumed to consist of 3.5 percent water-soluble material and 1.5 percent screenings.

The calculated yields of pulp per cord of wood given in table 3 and the cords of wood required per ton of pulp given in table 4 may differ from those obtained in commercial operation for a number of reasons, some of which are pointed out in the footnotes. On the basis of pulpwood and wood-pulp statistics, the U. S. Tariff Commission reported in 1938 the average of cords of wood required to make one ton of air-dry pulp by the principal processes was: Sulfite pulp, 1.965 cords; sulfate pulp, 1.786 cords; soda pulp, 1.813 cords; and groundwood pulp, 0.973 cord.

A notable difference between softwoods and hardwoods is observed in their fiber length. In general, softwoods produce longer fibered pulps than hardwoods and are preferred for most kinds of paper for this reason. The fiber length, among other structural characteristics of fibers, has an influence on the strength and other properties of the pulp and of the paper in which the pulp is used. Tables 1 and 2 contain reported values for the average fiber length of a number of the species.

Table 1.--Typical values of average fiber length, density, and yields of chemical pulp for various softwoods¹

Species	Average fiber length Mm.	Density ² lb. per cu. ft.	Yield of chemical pulp ³		Species	Average fiber length Mm.	Density ² lb. per cu. ft.	Yield of chemical pulp ³	
			Sulfite ⁴ , Percent	Sulfate ⁵ , Percent				Sulfite ⁴ , Percent	Sulfate ⁵ , Percent
Spruce (<i>Picea</i> sp.)									
White (<i>P. glauca</i>)	3.50	23	48	50	Hemlock (<i>Tsuga</i> sp.)	4.00	25	46	47
Black (<i>P. mariana</i>)	3.50	25	48	50	Western (<i>T. heterophylla</i>)	3.50	24	44	45
Red (<i>P. rubens</i>)	3.70	24	48	50	Eastern (<i>T. canadensis</i>)	3.10	30	48	45
Blue (<i>P. pungens</i>)	2.80	23	48	43	Carolina (<i>T. caroliniana</i>)	3.70	26	.....	45
Angelmann (<i>P. engelmannii</i>)	3.50	20	48	47	Mountain (<i>T. mertensiana</i>)				
Norway (<i>P. abies</i>)	.....	30	48	48					
Sitka (<i>P. sitchensis</i>)	5.50	24	48	47	Fir (<i>Abies</i> sp.)	3.15	21	48	48
					Alpine (<i>A. lasiocarpa</i>)	3.50	21	47	50
Pine (<i>Pinus</i> sp.)					Balsam (<i>A. balsamea</i>)	3.25	23	48	48
Loblolly (<i>P. taeda</i>)	4.00	29	45	48	California red (<i>A. magnifica</i>)				
Longleaf (<i>P. palustris</i>)	4.00	29	45	48	Noble (<i>A. procera</i>)	4.00	22	48	47
Shortleaf (<i>P. schinata</i>)	4.00	29	45	48	Graeb (<i>A. grandis</i>)	5.00	24	49	48
Slash (<i>P. caribaea</i>)	4.00	29	45	48	Pacific silver (<i>A. amabilis</i>)	3.55	24	49	42
Sand (<i>P. clausa</i>)	2.85	29	46	47	White (<i>A. concolor</i>)	3.50	22	48	48
Pond (<i>P. rigida</i>)	3.55	29	43	48					
Virginia (<i>P. virginiana</i>)	2.80	26	43	48	Douglas-fir (<i>Pseudotsuga taxifolia</i>)	4.50	29	48	48
Jack (<i>P. banksiana</i>)	3.50	24	45	48					
Red (<i>P. resinosa</i>)	3.70	27	45	48	Larch (<i>Larix</i> sp.)	3.50	31	42	48
White, eastern (<i>P. strobus</i>)	3.70	20	.....	48	Eastern (<i>L. laricina</i>)	5.00	27	42	48
White, western (<i>P. monticola</i>)	4.40	23	45	48	Western (<i>L. occidentalis</i>)				
Lodgepole (<i>P. contorta</i>)	3.50	25	45	48					
Ponderosa (<i>P. ponderosa</i>)	3.60	24	45	48	Cedars				
Sugar (<i>P. lambertiana</i>)	4.10	23	45	48	California incense-cedar, (<i>Libocedrus decurrens</i>)	2.00	22	40	45
Pinon (<i>P. edulis</i>)	2.00	31	40	45	White-cedar (<i>Chamaecyparis</i> sp.)				
Limber (<i>P. flexilis</i>)	2.95	25	.....	48	Port-Orford (<i>C. lawsoniana</i>)	2.60	26	45	45
Monterey (<i>P. radiata</i>)	2.60	29	45	48	Atlantic (<i>C. thyoides</i>)	2.10	20	.....	45
					Redcedar, eastern (<i>Juniperus virginiana</i>)	2.80	27	.....	45
					Redcedar, western (<i>J. plicata</i>)	3.80	19	43	40
					Redwood (<i>Sequoia sempervirens</i>)	7.00	23	.....	38
					Baldcypress (<i>Taxodium distichum</i>)	6.00	27	46	48

¹Considerable variation between samples of the same species can be expected.

²Moisture-free weight, green volume.

³Yields of moisture-free, screened pulp based on weight of moisture-free wood. Screenings, which may amount to about 0.5 percent, are frequently refined and returned to the pulp system or converted into lower grade products and therefore are not always actually lost.

⁴Bleachable pulp of papermaking grade.

⁵Yields given for sulfite pulp made from the pines, Douglas-fir, and the larches are based on use of young wood essentially free from heartwood or on the use of a modification of the standard lime-base process.

⁶Craft-type, wrapping, and board grade; bleachable pulp may be 2 to 3 percent lower than the values given.

Table 3.--Weight, in pounds, of moisture-free pulp produced per cord of rough logs for various kinds and percentage yields of pulp, and densities of wood.

Density: Wood of wood ² per cord ²	Yield of chemical pulp ⁴																	Yield of semichemical pulp ⁴																	: Yield : of : ground- : wood, : pulp ⁴
	: 35	: 38	: 40	: 41	: 42	: 43	: 44	: 45	: 46	: 47	: 48	: 49	: 50	: 55	: 60	: 65	: 70	: 75	: 80	: 85	: 90	: 95													
19	1,575	520	565	610	625	640	655	670	685	700	710	725	740	815	890	965	1,040	1,115	1,185	1,260	1,335	1,410													
20	1,660	545	595	640	655	670	685	705	720	735	750	765	780	860	935	1,015	1,095	1,170	1,250	1,330	1,405	1,485													
21	1,745	575	625	675	690	705	720	740	755	770	785	805	820	900	985	1,065	1,150	1,230	1,310	1,395	1,475	1,560													
22	1,825	600	655	705	720	740	755	775	790	810	825	840	860	945	1,030	1,115	1,205	1,290	1,375	1,460	1,545	1,635													
23	1,910	630	685	720	735	755	775	790	810	825	845	860	880	900	990	1,080	1,170	1,260	1,350	1,435	1,525	1,615													
24	1,990	655	710	750	770	785	805	825	845	860	880	900	920	955	1,050	1,125	1,220	1,310	1,405	1,500	1,595	1,685													
25	2,075	685	740	800	820	840	860	880	900	920	935	955	975	1,075	1,170	1,270	1,365	1,465	1,560	1,660	1,760	1,855													
26	2,160	710	835	875	895	915	935	955	975	995	1,015	1,115	1,220	1,320	1,420	1,525	1,625	1,725	1,830	1,930	2,035	2,140													
27	2,240	740	865	905	925	945	965	985	1,005	1,025	1,125	1,230	1,330	1,430	1,530	1,640	1,740	1,840	1,940	2,040	2,140	2,240													
28	2,325	765	895	935	955	975	995	1,015	1,035	1,055	1,155	1,260	1,360	1,460	1,560	1,670	1,770	1,870	1,970	2,070	2,170	2,270													
29	2,405	795	925	965	985	1,005	1,025	1,045	1,065	1,085	1,185	1,290	1,390	1,490	1,590	1,700	1,800	1,900	2,000	2,100	2,200	2,300													
30	2,490	820	950	990	1,010	1,030	1,050	1,070	1,090	1,110	1,210	1,310	1,410	1,510	1,610	1,720	1,820	1,920	2,020	2,120	2,220	2,320													
31	2,575	850	980	1,020	1,040	1,060	1,080	1,100	1,120	1,140	1,240	1,340	1,440	1,540	1,640	1,750	1,850	1,950	2,050	2,150	2,250	2,350													
32	2,655	875	1,005	1,045	1,065	1,085	1,105	1,125	1,145	1,165	1,265	1,365	1,465	1,565	1,665	1,775	1,875	1,975	2,075	2,175	2,275	2,375													
33	2,740	900	1,030	1,070	1,090	1,110	1,130	1,150	1,170	1,190	1,290	1,390	1,490	1,590	1,690	1,800	1,900	2,000	2,100	2,200	2,300	2,400													
34	2,820	930	1,060	1,100	1,120	1,140	1,160	1,180	1,200	1,220	1,320	1,420	1,520	1,620	1,720	1,830	1,930	2,030	2,130	2,230	2,330	2,430													
35	2,905	955	1,085	1,125	1,145	1,165	1,185	1,205	1,225	1,245	1,345	1,445	1,545	1,645	1,745	1,855	1,955	2,055	2,155	2,255	2,355	2,455													
36	2,990	980	1,110	1,150	1,170	1,190	1,210	1,230	1,250	1,270	1,370	1,470	1,570	1,670	1,770	1,880	1,980	2,080	2,180	2,280	2,380	2,480													
37	3,070	1,010	1,140	1,180	1,200	1,220	1,240	1,260	1,280	1,300	1,400	1,500	1,600	1,700	1,800	1,910	2,010	2,110	2,210	2,310	2,410	2,510													
38	3,155	1,040	1,170	1,210	1,230	1,250	1,270	1,290	1,310	1,330	1,430	1,530	1,630	1,730	1,830	1,940	2,040	2,140	2,240	2,340	2,440	2,540													
39	3,235	1,065	1,195	1,235	1,255	1,275	1,295	1,315	1,335	1,355	1,455	1,555	1,655	1,755	1,855	1,965	2,065	2,165	2,265	2,365	2,465	2,565													
40	3,320	1,095	1,185	1,225	1,245	1,265	1,285	1,305	1,325	1,345	1,445	1,545	1,645	1,745	1,845	1,955	2,055	2,155	2,255	2,355	2,455	2,555													

¹The product of the percentage yield (divided by 100), the density, and 85 cubic feet of wood per cord (see footnote 3) corrected for the following additional losses representative of commercial practice: For chemical and semichemical pulps, 2 percent loss of wood in barking, 2 percent loss of wood in chipping, and 2 percent loss of fiber in washing the pulp. The additional losses used in computing the groundwood pulp figures were: 2 percent loss of wood in barking and 2.5 percent loss of fiber in the white water. The results are expressed to the nearest 5 pounds. Commercial production is usually based on air-dry pulp having an assumed moisture content of 10 percent. To convert the moisture-free values given in the table to air-dry values, multiply by 1.11. The pounds of pulp obtained per cord of bark-free logs are from 1.15 to 1.20 times the amount for a cord of logs with the bark on.

²Pounds of moisture-free wood per cubic foot, green volume. The density of wood is influenced by the amounts of springwood and summerwood, the amount of heartwood, the rate of growth, age, location of wood in the tree, and other factors.

³Pounds moisture-free wood in a standard cord (128 cubic feet) of rough logs. Figures in this column are the product of the density and the cubic feet of solid wood per cord expressed to the nearest 5 pounds. The factor of 85 cubic feet of solid wood per cord used is based on an average volume of 65 percent wood and 35 percent bark and air space in a freshly stacked pile of rough 4-foot logs with average diameter inside bark per cord ranging from 7 to 10 inches and with number of logs ranging between 45 and 100 per cord. The factor will vary with length, diameter, crook, knottiness, bark thickness, size of pile, and closeness of piling from as low as 75 to as high as 95 or more cubic feet per standard cord. The solid-volume content of a cord of bark-free logs is from 1.15 to 1.20 times (depending on bark thickness) that for a cord of logs of the same average diameter with the bark on.

⁴Percent of moisture-free wood.

Table 4.--Cords of rough logs required per ton of moisture-free pulp for various kinds and percentage yields of pulp, and densities of wood¹

Density: of wood ²	Yield of chemical pulp ³										Yield of semichemical pulp ²										:Yield : of :ground- : wood : pulp ²																																													
	: 35	: 38	: 40	: 41	: 42	: 43	: 44	: 45	: 46	: 47	: 48	: 49	: 50	: 55	: 60	: 65	: 70	: 75	: 80	: 85		: 90	: 95																																											
19	: 3.845	: 3.540	: 3.360	: 3.280	: 3.200	: 3.125	: 3.055	: 2.985	: 2.920	: 2.855	: 2.780	: 2.720	: 2.665	: 2.615	: 2.565	: 2.525	: 2.475	: 2.425	: 2.375	: 2.325	: 2.275	: 2.225	: 2.175	: 2.125	: 2.075	: 2.025	: 1.975	: 1.925	: 1.875	: 1.825	: 1.775	: 1.725	: 1.675	: 1.625	: 1.575	: 1.525	: 1.475	: 1.425	: 1.375	: 1.325	: 1.275	: 1.225	: 1.175	: 1.125	: 1.075	: 1.025	: 0.975	: 0.925	: 0.875	: 0.825	: 0.775	: 0.725	: 0.675	: 0.625	: 0.575	: 0.525	: 0.475	: 0.425	: 0.375	: 0.325	: 0.275	: 0.225	: 0.175	: 0.125	: 0.075	: 0.025
20	: 3.670	: 3.360	: 3.200	: 3.125	: 3.055	: 2.985	: 2.920	: 2.855	: 2.780	: 2.720	: 2.665	: 2.615	: 2.565	: 2.525	: 2.475	: 2.425	: 2.375	: 2.325	: 2.275	: 2.225	: 2.175	: 2.125	: 2.075	: 2.025	: 1.975	: 1.925	: 1.875	: 1.825	: 1.775	: 1.725	: 1.675	: 1.625	: 1.575	: 1.525	: 1.475	: 1.425	: 1.375	: 1.325	: 1.275	: 1.225	: 1.175	: 1.125	: 1.075	: 1.025	: 0.975	: 0.925	: 0.875	: 0.825	: 0.775	: 0.725	: 0.675	: 0.625	: 0.575	: 0.525	: 0.475	: 0.425	: 0.375	: 0.325	: 0.275	: 0.225	: 0.175	: 0.125	: 0.075	: 0.025		
21	: 3.480	: 3.200	: 3.055	: 2.965	: 2.900	: 2.835	: 2.780	: 2.705	: 2.650	: 2.595	: 2.550	: 2.485	: 2.440	: 2.385	: 2.340	: 2.290	: 2.240	: 2.190	: 2.140	: 2.090	: 2.040	: 1.990	: 1.940	: 1.890	: 1.840	: 1.790	: 1.740	: 1.690	: 1.640	: 1.590	: 1.540	: 1.490	: 1.440	: 1.390	: 1.340	: 1.290	: 1.240	: 1.190	: 1.140	: 1.090	: 1.040	: 0.990	: 0.940	: 0.890	: 0.840	: 0.790	: 0.740	: 0.690	: 0.640	: 0.590	: 0.540	: 0.490	: 0.440	: 0.390	: 0.340	: 0.290	: 0.240	: 0.190	: 0.140	: 0.090	: 0.040					
22	: 3.335	: 3.055	: 2.920	: 2.835	: 2.780	: 2.705	: 2.650	: 2.580	: 2.530	: 2.470	: 2.425	: 2.380	: 2.325	: 2.280	: 2.230	: 2.180	: 2.130	: 2.080	: 2.030	: 1.980	: 1.930	: 1.880	: 1.830	: 1.780	: 1.730	: 1.680	: 1.630	: 1.580	: 1.530	: 1.480	: 1.430	: 1.380	: 1.330	: 1.280	: 1.230	: 1.180	: 1.130	: 1.080	: 1.030	: 0.980	: 0.930	: 0.880	: 0.830	: 0.780	: 0.730	: 0.680	: 0.630	: 0.580	: 0.530	: 0.480	: 0.430	: 0.380	: 0.330	: 0.280	: 0.230	: 0.180	: 0.130	: 0.080	: 0.030							
23	: 3.175	: 2.920	: 2.780	: 2.720	: 2.650	: 2.580	: 2.530	: 2.470	: 2.425	: 2.365	: 2.320	: 2.275	: 2.220	: 2.175	: 2.125	: 2.075	: 2.025	: 1.975	: 1.925	: 1.875	: 1.825	: 1.775	: 1.725	: 1.675	: 1.625	: 1.575	: 1.525	: 1.475	: 1.425	: 1.375	: 1.325	: 1.275	: 1.225	: 1.175	: 1.125	: 1.075	: 1.025	: 0.975	: 0.925	: 0.875	: 0.825	: 0.775	: 0.725	: 0.675	: 0.625	: 0.575	: 0.525	: 0.475	: 0.425	: 0.375	: 0.325	: 0.275	: 0.225	: 0.175	: 0.125	: 0.075	: 0.025									
24	: 3.055	: 2.815	: 2.665	: 2.595	: 2.550	: 2.485	: 2.425	: 2.365	: 2.325	: 2.275	: 2.220	: 2.175	: 2.140	: 2.100	: 2.050	: 2.000	: 1.950	: 1.900	: 1.850	: 1.800	: 1.750	: 1.700	: 1.650	: 1.600	: 1.550	: 1.500	: 1.450	: 1.400	: 1.350	: 1.300	: 1.250	: 1.200	: 1.150	: 1.100	: 1.050	: 1.000	: 0.950	: 0.900	: 0.850	: 0.800	: 0.750	: 0.700	: 0.650	: 0.600	: 0.550	: 0.500	: 0.450	: 0.400	: 0.350	: 0.300	: 0.250	: 0.200	: 0.150	: 0.100	: 0.050											
25	: 2.920	: 2.705	: 2.565	: 2.500	: 2.440	: 2.380	: 2.325	: 2.275	: 2.220	: 2.175	: 2.140	: 2.095	: 2.050	: 2.000	: 1.950	: 1.900	: 1.850	: 1.800	: 1.750	: 1.700	: 1.650	: 1.600	: 1.550	: 1.500	: 1.450	: 1.400	: 1.350	: 1.300	: 1.250	: 1.200	: 1.150	: 1.100	: 1.050	: 1.000	: 0.950	: 0.900	: 0.850	: 0.800	: 0.750	: 0.700	: 0.650	: 0.600	: 0.550	: 0.500	: 0.450	: 0.400	: 0.350	: 0.300	: 0.250	: 0.200	: 0.150	: 0.100	: 0.050													
26	: 2.815	: 2.595	: 2.470	: 2.395	: 2.340	: 2.285	: 2.235	: 2.185	: 2.140	: 2.095	: 2.050	: 2.010	: 1.970	: 1.930	: 1.890	: 1.850	: 1.810	: 1.770	: 1.730	: 1.690	: 1.650	: 1.610	: 1.570	: 1.530	: 1.490	: 1.450	: 1.410	: 1.370	: 1.330	: 1.290	: 1.250	: 1.210	: 1.170	: 1.130	: 1.090	: 1.050	: 1.010	: 0.970	: 0.930	: 0.890	: 0.850	: 0.810	: 0.770	: 0.730	: 0.690	: 0.650	: 0.610	: 0.570	: 0.530	: 0.490	: 0.450	: 0.410	: 0.370	: 0.330	: 0.290	: 0.250	: 0.210	: 0.170	: 0.130	: 0.090	: 0.050					
27	: 2.705	: 2.500	: 2.365	: 2.310	: 2.260	: 2.210	: 2.150	: 2.105	: 2.060	: 2.020	: 1.980	: 1.940	: 1.900	: 1.860	: 1.820	: 1.780	: 1.740	: 1.700	: 1.660	: 1.620	: 1.580	: 1.540	: 1.500	: 1.460	: 1.420	: 1.380	: 1.340	: 1.300	: 1.260	: 1.220	: 1.180	: 1.140	: 1.100	: 1.060	: 1.020	: 0.980	: 0.940	: 0.900	: 0.860	: 0.820	: 0.780	: 0.740	: 0.700	: 0.660	: 0.620	: 0.580	: 0.540	: 0.500	: 0.460	: 0.420	: 0.380	: 0.340	: 0.300	: 0.260	: 0.220	: 0.180	: 0.140	: 0.100	: 0.060	: 0.020						
28	: 2.615	: 2.410	: 2.285	: 2.235	: 2.175	: 2.130	: 2.085	: 2.040	: 1.990	: 1.940	: 1.895	: 1.850	: 1.805	: 1.760	: 1.715	: 1.670	: 1.625	: 1.580	: 1.535	: 1.490	: 1.445	: 1.400	: 1.355	: 1.310	: 1.265	: 1.220	: 1.175	: 1.130	: 1.085	: 1.040	: 0.995	: 0.950	: 0.905	: 0.860	: 0.815	: 0.770	: 0.725	: 0.680	: 0.635	: 0.590	: 0.545	: 0.500	: 0.455	: 0.410	: 0.365	: 0.320	: 0.275	: 0.230	: 0.185	: 0.140	: 0.095	: 0.050														
29	: 2.515	: 2.325	: 2.210	: 2.150	: 2.105	: 2.050	: 2.010	: 1.960	: 1.925	: 1.880	: 1.845	: 1.800	: 1.760	: 1.720	: 1.680	: 1.640	: 1.600	: 1.560	: 1.520	: 1.480	: 1.440	: 1.400	: 1.360	: 1.320	: 1.280	: 1.240	: 1.200	: 1.160	: 1.120	: 1.080	: 1.040	: 1.000	: 0.960	: 0.920	: 0.880	: 0.840	: 0.800	: 0.760	: 0.720	: 0.680	: 0.640	: 0.600	: 0.560	: 0.520	: 0.480	: 0.440	: 0.400	: 0.360	: 0.320	: 0.280	: 0.240	: 0.200	: 0.160	: 0.120	: 0.080	: 0.040										
30	: 2.440	: 2.245	: 2.140	: 2.085	: 2.030	: 1.980	: 1.940	: 1.895	: 1.850	: 1.810	: 1.770	: 1.730	: 1.690	: 1.650	: 1.610	: 1.570	: 1.530	: 1.490	: 1.450	: 1.410	: 1.370	: 1.330	: 1.290	: 1.250	: 1.210	: 1.170	: 1.130	: 1.090	: 1.050	: 1.010	: 0.970	: 0.930	: 0.890	: 0.850	: 0.810	: 0.770	: 0.730	: 0.690	: 0.650	: 0.610	: 0.570	: 0.530	: 0.490	: 0.450	: 0.410	: 0.370	: 0.330	: 0.290	: 0.250	: 0.210	: 0.170	: 0.130	: 0.090	: 0.050												
31	: 2.355	: 2.175	: 2.060	: 2.010	: 1.970	: 1.925	: 1.880	: 1.835	: 1.795	: 1.755	: 1.725	: 1.690	: 1.655	: 1.620	: 1.585	: 1.550	: 1.515	: 1.480	: 1.445	: 1.410	: 1.375	: 1.340	: 1.305	: 1.270	: 1.235	: 1.200	: 1.165	: 1.130	: 1.095	: 1.060	: 1.025	: 0.990	: 0.955	: 0.920	: 0.885	: 0.850	: 0.815	: 0.780	: 0.745	: 0.710	: 0.675	: 0.640	: 0.605	: 0.570	: 0.535	: 0.500	: 0.465	: 0.430	: 0.395	: 0.360	: 0.325	: 0.290	: 0.255	: 0.220	: 0.185	: 0.150	: 0.115	: 0.080	: 0.045							
32	: 2.285	: 2.105	: 2.000	: 1.950	: 1.905	: 1.860	: 1.820	: 1.780	: 1.740	: 1.700	: 1.665	: 1.635	: 1.600	: 1.565	: 1.530	: 1.495	: 1.460	: 1.425	: 1.390	: 1.355	: 1.320	: 1.285	: 1.250	: 1.215	: 1.180	: 1.145	: 1.110	: 1.075	: 1.040	: 1.005	: 0.970	: 0.935	: 0.900	: 0.865	: 0.830	: 0.795	: 0.760	: 0.725	: 0.690	: 0.655	: 0.620	: 0.585	: 0.550	: 0.515	: 0.480	: 0.445	: 0.410	: 0.375	: 0.340	: 0.305	: 0.270	: 0.235	: 0.200	: 0.165	: 0.130	: 0.095	: 0.060									
33	: 2.220	: 2.040	: 1.940	: 1.895	: 1.845	: 1.800	: 1.760	: 1.725	: 1.690	: 1.655	: 1.620	: 1.585	: 1.550	: 1.515	: 1.480	: 1.445	: 1.410	: 1.375	: 1.340	: 1.305	: 1.270	: 1.235	: 1.200	: 1.165	: 1.130	: 1.095	: 1.060	: 1.025	: 0.990	: 0.955	: 0.920	: 0.885	: 0.850	: 0.815	: 0.780	: 0.745	: 0.710	: 0.675	: 0.640	: 0.605	: 0.570	: 0.535	: 0.500	: 0.465	: 0.430	: 0.395	: 0.360	: 0.325	: 0.290	: 0.255	: 0.220	: 0.185	: 0.150	: 0.115	: 0.080	: 0.045										
34	: 2.150	: 1.980	: 1.885	: 1.835	: 1.795	: 1.755	: 1.715	: 1.675	: 1.640	: 1.600	: 1.570	: 1.540	: 1.505	: 1.470	: 1.435	: 1.400	: 1.365	: 1.330	: 1.295	: 1.260	: 1.225	: 1.190	: 1.155	: 1.120	: 1.085	: 1.050	: 1.015	: 0.980	: 0.945	: 0.910	: 0.875	: 0.840	: 0.805	: 0.770	: 0.735	: 0.700	: 0.665	: 0.630	: 0.595	: 0.560	: 0.525	: 0.490	: 0.455	: 0.420	: 0.385	: 0.350	: 0.315	: 0.280	: 0.245	: 0.210	: 0.175	: 0.140	: 0.105	: 0.070	: 0.035											
35	: 2.095	: 1.925	: 1.825	: 1.785	: 1.740	: 1.700	: 1.660	: 1.625	: 1.585	: 1.555	: 1.525	: 1.495	: 1.465	: 1.430	: 1.400	: 1.365	: 1.330	: 1.295	: 1.260	: 1.225	: 1.190	: 1.155	: 1.120	: 1.085	: 1.050	: 1.015	: 0.980	: 0.945	: 0.910	: 0.875	: 0.840	: 0.805	: 0.770	: 0.735	: 0.700	: 0.665	: 0.630	: 0.595	: 0.560	: 0.525	: 0.490	: 0.455	: 0.420	: 0.385	: 0.350	: 0.315	: 0.280	: 0.245	: 0.210	: 0.175	: 0.140	: 0.105	: 0.070	: 0.035												
36	: 2.030	: 1.870	: 1.780	: 1.730	: 1.695	: 1.655	: 1.620	: 1.580	: 1.545	: 1.515	: 1.480	: 1.450	: 1.425	: 1.395	: 1.365	: 1.330	: 1.295	: 1.260	: 1.225	: 1.190	: 1.155	: 1.120	: 1.085	: 1.050	: 1.015	: 0.980	: 0.945	: 0.910	: 0.875	: 0.840	: 0.805	: 0.770	: 0.735	: 0.700	: 0.665	: 0.630	: 0.595	: 0.560	: 0.525	: 0.490	: 0.455	: 0.420	: 0.385	: 0.350	: 0.315	: 0.280	: 0.245	: 0.210	: 0.175	: 0.140	: 0.105	: 0.070	: 0.035													
37	: 1.980	: 1.820	: 1.730	: 1.690	: 1.645	: 1.605	: 1.575	: 1.540	: 1.505	: 1.475	: 1.445	: 1.415	: 1.385	: 1.355	: 1.325	: 1.295	: 1.265	: 1.235	: 1.205	: 1.175	: 1.145	: 1.115	: 1.085	: 1.055	: 1.025	: 0.995	: 0.965	: 0.935	: 0.905	: 0.875	: 0.845																																			