

广州市花都区暴雨公式及计算图表

广州市水务局
广东省气候中心
二〇一四年三月

广州市花都区暴雨公式及计算图表

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说 明

1. 本计算图表以花都国家地面气象观测站 22 年(1991~2012 年)连续自记雨量记录为基础,利用国内先进的“降水数字化处理系统”得到高精度的原始数据而进行编制。

2. 以重现期 0.25、0.33、0.5、1、2、3、5、10、20、50、100(年)相应的单一重现期暴雨强度公式制表。设计暴雨强度可按选定设计重现期直接查用表列数值(单一重现期暴雨强度公式见表一)。

3. 若采用其它重现期,设计暴雨强度可用重现期区间参数公式计算:

$$q = \frac{167A}{(t+b)^n}$$

式中: q —设计暴雨强度(升/秒·公顷)

t —降雨历时(分钟)

A —雨力

b 、 n —地方常数

(A 、 b 、 n 按重现期区间参数公式计算,公式见表二)

4. 考虑到绘制全国城市暴雨公式等值线图,列出包含重现期在内的暴雨强度总公式:

$$q = \frac{2017.873(1 + 0.582 \ln P)}{(t + 9.437)^{0.716}}$$

因总公式精度不及重现期区间参数公式,故建议推求其它重现期设计暴雨强度时使用区间参数公式。

应用重现期区间参数公式计算暴雨强度实例:求 $P=25$ 年, $t=50$ 分钟的暴雨强度 q 。

从重现期区间参数公式 III, 得:

$$n = 0.774 - 0.048 \ln(P - 6.571)$$

$$= 0.63413 \text{ (取 } 0.634)$$

$$b = 12.622 - 1.699 \ln(P - 8.302)$$

$$= 7.83882 \text{ (取 } 7.839)$$

$$A = 30.259 - 2.398 \ln(P - 8.683)$$

$$= 23.56329 \text{ (取 } 23.563)$$

配得 $P=25$ 年的暴雨强度计算公式如下:

$$q = \frac{167 \times 23.563}{(t + 7.839)^{0.634}}$$

可按上式计算 1~200 分钟中任何时段的暴雨强度。

当 $t=50$:

$$q = \frac{3935.021}{(t + 7.839)^{0.634}} = 300.399 \text{ (升/秒/公顷)}$$

5. 公式误差

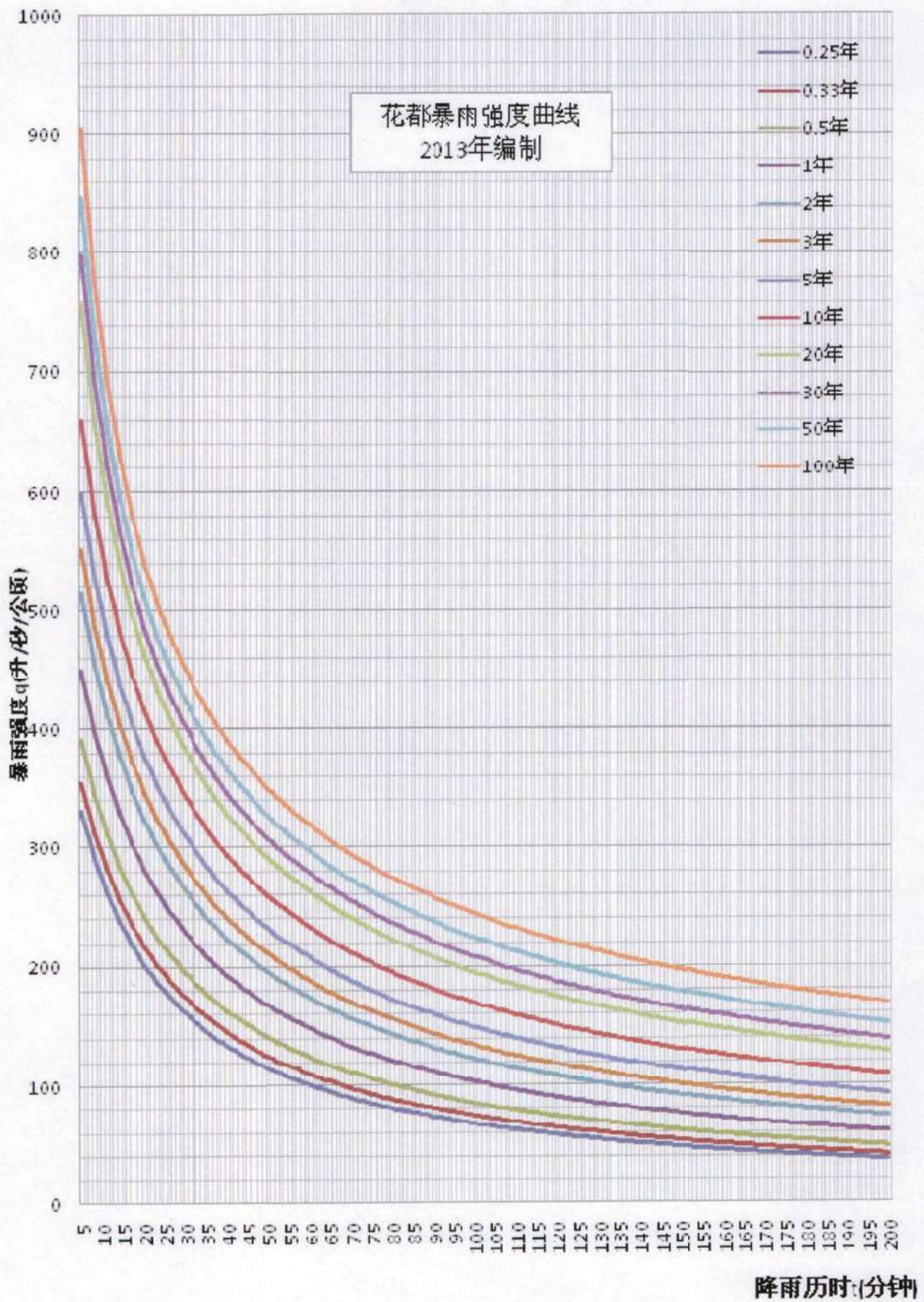
重现期 0.25~10 年的暴雨强度公式算得的平均绝对均方差为: 0.042 (mm/min), 平均相对均方差为: 4.08%。精度符合《室外排水设计规范》(GB50014—2006, 2011 年版)提出的要求。

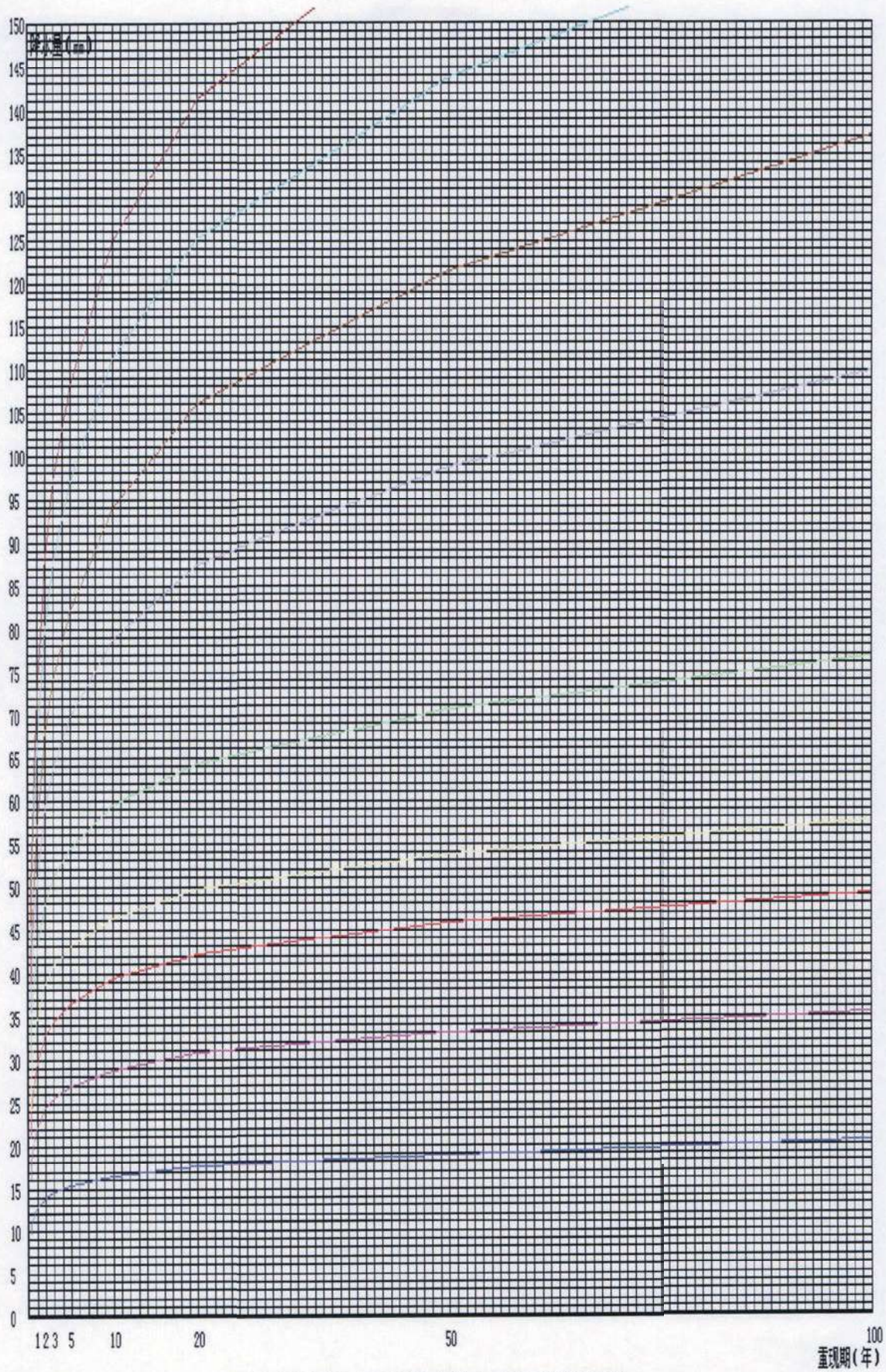
表一 单一重现期暴雨强度公式

重现期 P (年)	公 式
P=0.25	$6943.501/(t+17.808)^{0.973}$
P=0.33	$6742.627/(t+17.408)^{0.947}$
P=0.5	$6578.225/(t+16.943)^{0.914}$
P=1	$6390.262/(t+16.312)^{0.868}$
P=2	$5896.873/(t+14.767)^{0.817}$
P=3	$5642.374/(t+13.959)^{0.790}$
P=5	$5338.696/(t+12.990)^{0.757}$
P=10	$4942.912/(t+11.722)^{0.715}$
P=20	$4081.600/(t+8.443)^{0.649}$
P=30	$3828.025/(t+7.394)^{0.623}$
P=50	$3563.010/(t+6.284)^{0.593}$
P=100	$3245.415/(t+4.945)^{0.556}$

表二 重现期区间暴雨强度公式

P (年)	区间	参数	公 式
0.25—1	I	n	$0.861 - 0.055\text{Ln}(P-0.119)$
		b	$16.201 - 0.722\text{Ln}(P-0.142)$
		A	$38.002 - 1.128\text{Ln}(P-0.208)$
1 — 10	II	n	$0.849 - 0.059\text{Ln}(P-0.272)$
		b	$15.702 - 1.751\text{Ln}(P-0.294)$
		A	$36.998 - 3.260\text{Ln}(P-0.322)$
10—100	III	n	$0.774 - 0.048\text{Ln}(P-6.571)$
		b	$12.622 - 1.699\text{Ln}(P-8.302)$
		A	$30.259 - 2.398\text{Ln}(P-8.683)$





延长样本资料后的降水量与重现期曲线图

P=0.25(年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	399.616	26	175.528	51	113.124	76	83.674	101	66.490	126	55.215	151	47.242	176	41.302
2	379.973	27	171.716	52	111.547	77	82.815	102	65.950	127	54.844	152	46.971	177	41.095
3	362.193	28	168.067	53	110.014	78	81.974	103	65.418	128	54.478	153	46.703	178	40.891
4	346.023	29	164.572	54	108.523	79	81.150	104	64.896	129	54.117	154	46.439	179	40.689
5	331.253	30	161.222	55	107.073	80	80.342	105	64.381	130	53.760	155	46.177	180	40.489
6	317.707	31	158.007	56	105.661	81	79.551	106	63.875	131	53.409	156	45.919	181	40.290
7	305.239	32	154.920	57	104.286	82	78.775	107	63.377	132	53.062	157	45.663	182	40.094
8	293.725	33	151.952	58	102.947	83	78.015	108	62.887	133	52.720	158	45.410	183	39.900
9	283.059	34	149.098	59	101.643	84	77.269	109	62.405	134	52.382	159	45.161	184	39.708
10	273.150	35	146.350	60	100.372	85	76.538	110	61.929	135	52.048	160	44.913	185	39.517
11	263.920	36	143.703	61	99.132	86	75.820	111	61.462	136	51.719	161	44.669	186	39.328
12	255.301	37	141.151	62	97.924	87	75.116	112	61.001	137	51.394	162	44.427	187	39.142
13	247.234	38	138.689	63	96.744	88	74.426	113	60.547	138	51.073	163	44.188	188	38.956
14	239.668	39	136.313	64	95.593	89	73.747	114	60.100	139	50.756	164	43.952	189	38.773
15	232.557	40	134.018	65	94.470	90	73.082	115	59.660	140	50.443	165	43.718	190	38.592
16	225.862	41	131.800	66	93.373	91	72.428	116	59.226	141	50.134	166	43.486	191	38.412
17	219.546	42	129.656	67	92.302	92	71.786	117	58.798	142	49.828	167	43.257	192	38.234
18	213.578	43	127.581	68	91.255	93	71.156	118	58.377	143	49.527	168	43.031	193	38.057
19	207.930	44	125.572	69	90.232	94	70.537	119	57.962	144	49.229	169	42.807	194	37.882
20	202.577	45	123.626	70	89.232	95	69.928	120	57.553	145	48.935	170	42.585	195	37.709
21	197.496	46	121.740	71	88.254	96	69.330	121	57.149	146	48.644	171	42.365	196	37.537
22	192.667	47	119.912	72	87.298	97	68.743	122	56.751	147	48.357	172	42.148	197	37.367
23	188.072	48	118.139	73	86.362	98	68.165	123	56.359	148	48.073	173	41.933	198	37.199
24	183.693	49	116.418	74	85.447	99	67.597	124	55.972	149	47.793	174	41.720	199	37.032
25	179.517	50	114.747	75	84.551	100	67.039	125	55.591	150	47.516	175	41.510	200	36.867

P=0.33(年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	427.433	26	189.693	51	123.306	76	91.807	101	73.339	126	61.172	151	52.537	176	46.083
2	406.548	27	185.645	52	121.623	77	90.886	102	72.758	127	60.771	152	52.243	177	45.858
3	387.657	28	181.771	53	119.986	78	89.983	103	72.185	128	60.375	153	51.953	178	45.636
4	370.488	29	178.060	54	118.394	79	89.099	104	71.622	129	59.985	154	51.666	179	45.416
5	354.811	30	174.501	55	116.845	80	88.233	105	71.068	130	59.599	155	51.382	180	45.198
6	340.440	31	171.085	56	115.337	81	87.383	106	70.522	131	59.219	156	51.101	181	44.982
7	327.217	32	167.804	57	113.869	82	86.551	107	69.985	132	58.843	157	50.824	182	44.769
8	315.008	33	164.650	58	112.438	83	85.734	108	69.457	133	58.473	158	50.549	183	44.557
9	303.701	34	161.616	59	111.044	84	84.933	109	68.936	134	58.107	159	50.278	184	44.347
10	293.197	35	158.694	60	109.685	85	84.148	110	68.424	135	57.746	160	50.009	185	44.140
11	283.414	36	155.878	61	108.360	86	83.377	111	67.919	136	57.389	161	49.744	186	43.934
12	274.279	37	153.164	62	107.068	87	82.621	112	67.422	137	57.037	162	49.481	187	43.731
13	265.729	38	150.545	63	105.806	88	81.878	113	66.932	138	56.690	163	49.222	188	43.529
14	257.710	39	148.016	64	104.575	89	81.149	114	66.450	139	56.346	164	48.965	189	43.329
15	250.174	40	145.573	65	103.373	90	80.434	115	65.975	140	56.007	165	48.710	190	43.132
16	243.076	41	143.212	66	102.199	91	79.731	116	65.506	141	55.672	166	48.459	191	42.936
17	236.381	42	140.928	67	101.052	92	79.040	117	65.044	142	55.342	167	48.210	192	42.741
18	230.054	43	138.718	68	99.931	93	78.362	118	64.590	143	55.015	168	47.964	193	42.549
19	224.066	44	136.578	69	98.835	94	77.696	119	64.141	144	54.692	169	47.720	194	42.358
20	218.390	45	134.504	70	97.764	95	77.041	120	63.699	145	54.373	170	47.479	195	42.169
21	213.001	46	132.495	71	96.717	96	76.398	121	63.263	146	54.058	171	47.240	196	41.982
22	207.879	47	130.546	72	95.692	97	75.765	122	62.833	147	53.746	172	47.004	197	41.797
23	203.004	48	128.655	73	94.689	98	75.144	123	62.409	148	53.439	173	46.770	198	41.613
24	198.358	49	126.820	74	93.708	99	74.532	124	61.991	149	53.135	174	46.539	199	41.431
25	193.926	50	125.037	75	92.747	100	73.931	125	61.579	150	52.834	175	46.309	200	41.251

P=0.5(年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	469.947	26	211.663	51	139.164	76	104.510	101	84.062	126	70.516	151	60.857	176	53.608
2	447.219	27	207.256	52	137.318	77	103.493	102	83.416	127	70.068	152	60.528	177	53.355
3	426.678	28	203.037	53	135.523	78	102.496	103	82.780	128	69.626	153	60.202	178	53.105
4	408.018	29	198.994	54	133.776	79	101.519	104	82.154	129	69.190	154	59.880	179	52.857
5	390.989	30	195.116	55	132.075	80	100.562	105	81.538	130	68.760	155	59.562	180	52.612
6	375.383	31	191.393	56	130.419	81	99.623	106	80.932	131	68.335	156	59.247	181	52.369
7	361.027	32	187.816	57	128.806	82	98.702	107	80.335	132	67.915	157	58.935	182	52.128
8	347.774	33	184.375	58	127.234	83	97.799	108	79.747	133	67.501	158	58.627	183	51.890
9	335.501	34	181.065	59	125.702	84	96.913	109	79.168	134	67.092	159	58.323	184	51.654
10	324.102	35	177.876	60	124.208	85	96.044	110	78.598	135	66.689	160	58.022	185	51.420
11	313.484	36	174.803	61	122.751	86	95.191	111	78.036	136	66.290	161	57.723	186	51.188
12	303.569	37	171.838	62	121.329	87	94.353	112	77.483	137	65.896	162	57.429	187	50.959
13	294.290	38	168.977	63	119.941	88	93.531	113	76.938	138	65.508	163	57.137	188	50.731
14	285.585	39	166.215	64	118.586	89	92.724	114	76.400	139	65.124	164	56.848	189	50.506
15	277.402	40	163.545	65	117.262	90	91.931	115	75.871	140	64.744	165	56.562	190	50.283
16	269.695	41	160.963	66	115.970	91	91.153	116	75.349	141	64.369	166	56.280	191	50.062
17	262.424	42	158.465	67	114.706	92	90.388	117	74.835	142	63.999	167	56.000	192	49.843
18	255.551	43	156.047	68	113.471	93	89.636	118	74.328	143	63.633	168	55.723	193	49.626
19	249.045	44	153.705	69	112.264	94	88.897	119	73.828	144	63.272	169	55.449	194	49.411
20	242.876	45	151.436	70	111.083	95	88.171	120	73.335	145	62.915	170	55.178	195	49.198
21	237.019	46	149.235	71	109.928	96	87.457	121	72.849	146	62.562	171	54.910	196	48.986
22	231.450	47	147.100	72	108.798	97	86.755	122	72.370	147	62.213	172	54.644	197	48.777
23	226.148	48	145.029	73	107.692	98	86.065	123	71.897	148	61.868	173	54.381	198	48.570
24	221.094	49	143.017	74	106.609	99	85.387	124	71.430	149	61.527	174	54.121	199	48.364
25	216.271	50	141.063	75	105.549	100	84.719	125	70.970	150	61.190	175	53.863	200	48.160

P=1 (年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	537.815	26	247.599	51	165.476	76	125.798	101	102.171	126	86.398	151	75.075	176	66.527
2	512.229	27	242.629	52	163.371	77	124.627	102	101.421	127	85.875	152	74.688	177	66.229
3	489.126	28	237.869	53	161.323	78	123.479	103	100.683	128	85.358	153	74.305	178	65.933
4	468.155	29	233.306	54	159.330	79	122.354	104	99.956	129	84.848	154	73.926	179	65.640
5	449.027	30	228.927	55	157.389	80	121.251	105	99.241	130	84.344	155	73.551	180	65.349
6	431.506	31	224.721	56	155.498	81	120.168	106	98.536	131	83.847	156	73.181	181	65.062
7	415.393	32	220.678	57	153.655	82	119.107	107	97.842	132	83.356	157	72.814	182	64.777
8	400.522	33	216.788	58	151.859	83	118.065	108	97.159	133	82.871	158	72.451	183	64.495
9	386.751	34	213.043	59	150.107	84	117.043	109	96.485	134	82.393	159	72.093	184	64.215
10	373.960	35	209.435	60	148.398	85	116.039	110	95.822	135	81.920	160	71.737	185	63.938
11	362.046	36	205.955	61	146.730	86	115.054	111	95.168	136	81.453	161	71.386	186	63.664
12	350.920	37	202.598	62	145.103	87	114.087	112	94.524	137	80.991	162	71.039	187	63.392
13	340.505	38	199.356	63	143.513	88	113.137	113	93.889	138	80.536	163	70.695	188	63.122
14	330.733	39	196.224	64	141.961	89	112.204	114	93.264	139	80.085	164	70.354	189	62.855
15	321.545	40	193.196	65	140.444	90	111.287	115	92.647	140	79.640	165	70.017	190	62.591
16	312.889	41	190.266	66	138.962	91	110.386	116	92.039	141	79.201	166	69.684	191	62.329
17	304.720	42	187.431	67	137.513	92	109.501	117	91.439	142	78.766	167	69.354	192	62.069
18	296.997	43	184.685	68	136.096	93	108.631	118	90.848	143	78.337	168	69.027	193	61.812
19	289.682	44	182.024	69	134.711	94	107.776	119	90.265	144	77.913	169	68.703	194	61.556
20	282.745	45	179.444	70	133.355	95	106.935	120	89.690	145	77.493	170	68.383	195	61.303
21	276.156	46	176.942	71	132.028	96	106.108	121	89.123	146	77.079	171	68.066	196	61.053
22	269.888	47	174.513	72	130.729	97	105.295	122	88.563	147	76.669	172	67.752	197	60.804
23	263.919	48	172.156	73	129.458	98	104.495	123	88.011	148	76.264	173	67.442	198	60.558
24	258.227	49	169.865	74	128.213	99	103.708	124	87.466	149	75.863	174	67.134	199	60.314
25	252.793	50	167.640	75	126.993	100	102.933	125	86.929	150	75.467	175	66.829	200	60.072

P=2 (年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	619.528	26	285.102	51	192.890	76	148.250	101	121.527	126	103.585	151	90.634	176	80.807
2	589.172	27	279.512	52	190.526	77	146.929	102	120.676	127	102.988	152	90.190	177	80.463
3	561.936	28	274.161	53	188.226	78	145.633	103	119.838	128	102.398	153	89.750	178	80.122
4	537.351	29	269.033	54	185.987	79	144.363	104	119.013	129	101.816	154	89.316	179	79.784
5	515.037	30	264.113	55	183.806	80	143.118	105	118.201	130	101.241	155	88.886	180	79.449
6	494.683	31	259.388	56	181.681	81	141.895	106	117.401	131	100.673	156	88.460	181	79.117
7	476.037	32	254.848	57	179.610	82	140.696	107	116.612	132	100.112	157	88.039	182	78.788
8	458.884	33	250.481	58	177.591	83	139.519	108	115.836	133	99.558	158	87.623	183	78.463
9	443.048	34	246.276	59	175.622	84	138.364	109	115.070	134	99.011	159	87.210	184	78.140
10	428.378	35	242.226	60	173.700	85	137.230	110	114.316	135	98.471	160	86.803	185	77.820
11	414.746	36	238.321	61	171.825	86	136.116	111	113.573	136	97.937	161	86.399	186	77.504
12	402.043	37	234.553	62	169.994	87	135.023	112	112.841	137	97.409	162	85.999	187	77.190
13	390.174	38	230.915	63	168.206	88	133.948	113	112.119	138	96.888	163	85.604	188	76.879
14	379.057	39	227.400	64	166.459	89	132.893	114	111.407	139	96.373	164	85.212	189	76.570
15	368.621	40	224.002	65	164.753	90	131.856	115	110.705	140	95.864	165	84.825	190	76.264
16	358.803	41	220.715	66	163.084	91	130.836	116	110.013	141	95.361	166	84.441	191	75.962
17	349.548	42	217.533	67	161.453	92	129.834	117	109.330	142	94.863	167	84.062	192	75.661
18	340.808	43	214.452	68	159.857	93	128.849	118	108.657	143	94.372	168	83.686	193	75.364
19	332.540	44	211.466	69	158.296	94	127.880	119	107.993	144	93.886	169	83.313	194	75.069
20	324.704	45	208.570	70	156.769	95	126.928	120	107.338	145	93.406	170	82.945	195	74.776
21	317.268	46	205.762	71	155.274	96	125.991	121	106.691	146	92.931	171	82.580	196	74.486
22	310.200	47	203.036	72	153.811	97	125.069	122	106.054	147	92.461	172	82.219	197	74.199
23	303.474	48	200.390	73	152.377	98	124.162	123	105.424	148	91.997	173	81.861	198	73.914
24	297.063	49	197.818	74	150.973	99	123.270	124	104.803	149	91.537	174	81.506	199	73.631
25	290.945	50	195.320	75	149.598	100	122.392	125	104.190	150	91.083	175	81.155	200	73.351

P=3(年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	665.716	26	306.328	51	208.678	76	161.349	101	132.933	126	113.794	151	99.939	176	89.397
2	632.539	27	300.404	52	206.175	77	159.946	102	132.027	127	113.156	152	99.463	177	89.026
3	602.887	28	294.734	53	203.738	78	158.571	103	131.134	128	112.526	153	98.992	178	88.660
4	576.208	29	289.300	54	201.366	79	157.221	104	130.255	129	111.904	154	98.526	179	88.297
5	552.062	30	284.089	55	199.056	80	155.898	105	129.389	130	111.289	155	98.065	180	87.937
6	530.093	31	279.085	56	196.805	81	154.600	106	128.536	131	110.682	156	97.609	181	87.580
7	510.011	32	274.277	57	194.610	82	153.325	107	127.696	132	110.083	157	97.158	182	87.227
8	491.573	33	269.652	58	192.471	83	152.075	108	126.868	133	109.491	158	96.711	183	86.877
9	474.580	34	265.201	59	190.384	84	150.847	109	126.052	134	108.906	159	96.269	184	86.530
10	458.861	35	260.912	60	188.347	85	149.642	110	125.248	135	108.328	160	95.832	185	86.186
11	444.276	36	256.778	61	186.359	86	148.458	111	124.456	136	107.757	161	95.399	186	85.846
12	430.700	37	252.789	62	184.418	87	147.295	112	123.675	137	107.192	162	94.970	187	85.508
13	418.028	38	248.937	63	182.523	88	146.152	113	122.904	138	106.635	163	94.546	188	85.173
14	406.172	39	245.216	64	180.671	89	145.030	114	122.145	139	106.083	164	94.126	189	84.842
15	395.051	40	241.619	65	178.861	90	143.927	115	121.396	140	105.539	165	93.710	190	84.513
16	384.596	41	238.139	66	177.091	91	142.842	116	120.658	141	105.000	166	93.299	191	84.187
17	374.749	42	234.771	67	175.361	92	141.776	117	119.929	142	104.468	167	92.891	192	83.864
18	365.454	43	231.509	68	173.668	93	140.728	118	119.211	143	103.942	168	92.487	193	83.544
19	356.667	44	228.348	69	172.012	94	139.697	119	118.502	144	103.422	169	92.088	194	83.226
20	348.343	45	225.282	70	170.392	95	138.683	120	117.802	145	102.907	170	91.692	195	82.911
21	340.448	46	222.309	71	168.805	96	137.686	121	117.112	146	102.399	171	91.300	196	82.599
22	332.946	47	219.423	72	167.252	97	136.705	122	116.431	147	101.896	172	90.912	197	82.290
23	325.809	48	216.620	73	165.731	98	135.739	123	115.759	148	101.399	173	90.528	198	81.983
24	319.009	49	213.898	74	164.241	99	134.789	124	115.096	149	100.907	174	90.147	199	81.679
25	312.523	50	211.251	75	162.780	100	133.854	125	114.441	150	100.420	175	89.770	200	81.377

P=5 (年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	724.521	26	333.491	51	229.197	76	178.560	101	148.043	126	127.408	151	112.413	176	100.965
2	687.628	27	327.158	52	226.522	77	177.056	102	147.067	127	126.718	152	111.897	177	100.562
3	654.820	28	321.098	53	223.919	78	175.581	103	146.106	128	126.037	153	111.387	178	100.164
4	625.430	29	315.293	54	221.384	79	174.134	104	145.160	129	125.365	154	110.881	179	99.768
5	598.931	30	309.725	55	218.914	80	172.715	105	144.228	130	124.701	155	110.381	180	99.377
6	574.899	31	304.380	56	216.508	81	171.322	106	143.309	131	124.045	156	109.887	181	98.989
7	552.993	32	299.245	57	214.162	82	169.955	107	142.404	132	123.396	157	109.397	182	98.604
8	532.932	33	294.306	58	211.875	83	168.613	108	141.512	133	122.756	158	108.912	183	98.223
9	514.483	34	289.552	59	209.643	84	167.295	109	140.633	134	122.123	159	108.432	184	97.846
10	497.451	35	284.973	60	207.465	85	166.001	110	139.767	135	121.498	160	107.958	185	97.471
11	481.673	36	280.559	61	205.339	86	164.730	111	138.913	136	120.880	161	107.488	186	97.100
12	467.010	37	276.300	62	203.263	87	163.481	112	138.070	137	120.270	162	107.022	187	96.732
13	453.343	38	272.188	63	201.235	88	162.254	113	137.240	138	119.666	163	106.562	188	96.368
14	440.570	39	268.216	64	199.253	89	161.049	114	136.421	139	119.070	164	106.106	189	96.006
15	428.602	40	264.375	65	197.316	90	159.864	115	135.614	140	118.480	165	105.654	190	95.648
16	417.362	41	260.660	66	195.422	91	158.698	116	134.817	141	117.897	166	105.207	191	95.293
17	406.784	42	257.063	67	193.570	92	157.553	117	134.031	142	117.321	167	104.764	192	94.941
18	396.808	43	253.580	68	191.758	93	156.426	118	133.256	143	116.751	168	104.326	193	94.592
19	387.382	44	250.205	69	189.985	94	155.318	119	132.491	144	116.188	169	103.891	194	94.246
20	378.460	45	246.932	70	188.249	95	154.228	120	131.736	145	115.631	170	103.461	195	93.902
21	370.001	46	243.756	71	186.550	96	153.156	121	130.991	146	115.080	171	103.035	196	93.562
22	361.968	47	240.674	72	184.886	97	152.101	122	130.256	147	114.535	172	102.613	197	93.225
23	354.328	48	237.681	73	183.256	98	151.062	123	129.530	148	113.996	173	102.195	198	92.890
24	347.053	49	234.773	74	181.659	99	150.040	124	128.814	149	113.463	174	101.781	199	92.558
25	340.115	50	231.946	75	180.094	100	149.034	125	128.106	150	112.935	175	101.371	200	92.229

P=10(年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	802.095	26	368.738	51	256.347	76	201.679	101	168.576	126	146.082	151	129.658	176	117.063
2	759.853	27	361.904	52	253.464	77	200.051	102	167.515	127	145.328	152	129.091	177	116.619
3	722.581	28	355.366	53	250.658	78	198.454	103	166.470	128	144.583	153	128.530	178	116.179
4	689.414	29	349.104	54	247.925	79	196.888	104	165.440	129	143.848	154	127.975	179	115.743
5	659.678	30	343.101	55	245.262	80	195.350	105	164.425	130	143.122	155	127.426	180	115.311
6	632.843	31	337.339	56	242.667	81	193.842	106	163.425	131	142.404	156	126.882	181	114.883
7	608.487	32	331.805	57	240.137	82	192.361	107	162.440	132	141.695	157	126.344	182	114.459
8	586.264	33	326.483	58	237.669	83	190.906	108	161.469	133	140.994	158	125.811	183	114.038
9	565.893	34	321.361	59	235.262	84	189.478	109	160.511	134	140.302	159	125.284	184	113.622
10	547.141	35	316.428	60	232.912	85	188.076	110	159.567	135	139.617	160	124.762	185	113.208
11	529.814	36	311.673	61	230.617	86	186.697	111	158.637	136	138.941	161	124.245	186	112.799
12	513.747	37	307.086	62	228.376	87	185.343	112	157.719	137	138.272	162	123.733	187	112.392
13	498.802	38	302.657	63	226.187	88	184.013	113	156.814	138	137.611	163	123.227	188	111.990
14	484.858	39	298.378	64	224.047	89	182.704	114	155.921	139	136.958	164	122.725	189	111.591
15	471.815	40	294.242	65	221.955	90	181.418	115	155.040	140	136.312	165	122.228	190	111.195
16	459.582	41	290.241	66	219.909	91	180.154	116	154.171	141	135.673	166	121.736	191	110.802
17	448.084	42	286.368	67	217.908	92	178.910	117	153.314	142	135.041	167	121.248	192	110.413
18	437.252	43	282.616	68	215.951	93	177.687	118	152.468	143	134.417	168	120.766	193	110.027
19	427.028	44	278.980	69	214.034	94	176.484	119	151.633	144	133.799	169	120.287	194	109.645
20	417.359	45	275.455	70	212.159	95	175.300	120	150.809	145	133.188	170	119.814	195	109.265
21	408.199	46	272.034	71	210.322	96	174.135	121	149.996	146	132.584	171	119.345	196	108.889
22	399.507	47	268.714	72	208.522	97	172.988	122	149.193	147	131.986	172	118.880	197	108.515
23	391.247	48	265.489	73	206.760	98	171.859	123	148.400	148	131.394	173	118.419	198	108.145
24	383.384	49	262.356	74	205.032	99	170.748	124	147.618	149	130.809	174	117.963	199	107.778
25	375.890	50	259.309	75	203.339	100	169.654	125	146.845	150	130.231	175	117.511	200	107.414

P=20 (年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	950.570	26	410.442	51	288.031	76	229.346	101	193.819	126	169.593	151	151.824	176	138.129
2	890.457	27	402.889	52	284.929	77	227.600	102	192.679	127	168.780	152	151.209	177	137.645
3	839.147	28	395.679	53	281.911	78	225.888	103	191.555	128	167.976	153	150.600	178	137.166
4	794.738	29	388.788	54	278.973	79	224.208	104	190.448	129	167.182	154	149.998	179	136.690
5	755.851	30	382.194	55	276.111	80	222.559	105	189.356	130	166.397	155	149.402	180	136.219
6	721.461	31	375.877	56	273.322	81	220.941	106	188.281	131	165.622	156	148.811	181	135.752
7	690.786	32	369.819	57	270.605	82	219.353	107	187.221	132	164.855	157	148.227	182	135.289
8	663.222	33	364.003	58	267.954	83	217.793	108	186.176	133	164.098	158	147.649	183	134.830
9	638.290	34	358.413	59	265.369	84	216.261	109	185.145	134	163.349	159	147.076	184	134.375
10	615.610	35	353.037	60	262.846	85	214.756	110	184.129	135	162.609	160	146.508	185	133.924
11	594.871	36	347.861	61	260.384	86	213.278	111	183.127	136	161.878	161	145.947	186	133.476
12	575.820	37	342.874	62	257.979	87	211.825	112	182.139	137	161.155	162	145.390	187	133.033
13	558.247	38	338.064	63	255.629	88	210.397	113	181.164	138	160.440	163	144.839	188	132.593
14	541.975	39	333.422	64	253.334	89	208.993	114	180.203	139	159.733	164	144.294	189	132.157
15	526.856	40	328.939	65	251.090	90	207.612	115	179.254	140	159.033	165	143.753	190	131.724
16	512.765	41	324.606	66	248.895	91	206.255	116	178.318	141	158.342	166	143.218	191	131.295
17	499.593	42	320.415	67	246.749	92	204.920	117	177.394	142	157.658	167	142.688	192	130.869
18	487.249	43	316.359	68	244.649	93	203.607	118	176.482	143	156.982	168	142.162	193	130.447
19	475.651	44	312.430	69	242.595	94	202.315	119	175.582	144	156.312	169	141.642	194	130.029
20	464.730	45	308.624	70	240.583	95	201.043	120	174.694	145	155.651	170	141.126	195	129.614
21	454.424	46	304.933	71	238.613	96	199.792	121	173.817	146	154.996	171	140.615	196	129.202
22	444.679	47	301.352	72	236.684	97	198.560	122	172.951	147	154.348	172	140.109	197	128.793
23	435.449	48	297.876	73	234.794	98	197.347	123	172.096	148	153.707	173	139.607	198	128.388
24	426.690	49	294.500	74	232.941	99	196.153	124	171.251	149	153.073	174	139.110	199	127.986
25	418.366	50	291.220	75	231.126	100	194.978	125	170.417	150	152.445	175	138.618	200	127.587

P=30 (年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	1017.910	26	430.850	51	304.242	76	243.702	101	206.996	126	181.905	151	163.455	176	149.201
2	949.019	27	423.007	52	301.042	77	241.900	102	205.816	127	181.062	152	162.816	177	148.696
3	891.090	28	415.526	53	297.929	78	240.133	103	204.653	128	180.228	153	162.183	178	148.196
4	841.556	29	408.380	54	294.898	79	238.398	104	203.507	129	179.404	154	161.556	179	147.701
5	798.611	30	401.546	55	291.946	80	236.696	105	202.378	130	178.590	155	160.936	180	147.210
6	760.946	31	395.002	56	289.071	81	235.025	106	201.265	131	177.785	156	160.322	181	146.723
7	727.585	32	388.729	57	286.267	82	233.385	107	200.168	132	176.990	157	159.714	182	146.240
8	697.786	33	382.709	58	283.534	83	231.774	108	199.086	133	176.204	158	159.112	183	145.761
9	670.971	34	376.926	59	280.867	84	230.192	109	198.019	134	175.427	159	158.516	184	145.287
10	646.686	35	371.365	60	278.265	85	228.637	110	196.968	135	174.659	160	157.926	185	144.816
11	624.566	36	366.014	61	275.725	86	227.110	111	195.930	136	173.900	161	157.342	186	144.349
12	604.316	37	360.858	62	273.245	87	225.609	112	194.907	137	173.149	162	156.763	187	143.886
13	585.692	38	355.888	63	270.821	88	224.134	113	193.897	138	172.407	163	156.189	188	143.428
14	568.493	39	351.092	64	268.453	89	222.683	114	192.901	139	171.672	164	155.621	189	142.972
15	552.551	40	346.462	65	266.138	90	221.257	115	191.918	140	170.946	165	155.059	190	142.521
16	537.725	41	341.987	66	263.875	91	219.854	116	190.949	141	170.228	166	154.501	191	142.073
17	523.892	42	337.659	67	261.661	92	218.474	117	189.991	142	169.518	167	153.949	192	141.629
18	510.950	43	333.472	68	259.495	93	217.117	118	189.047	143	168.815	168	153.402	193	141.189
19	498.809	44	329.417	69	257.374	94	215.781	119	188.114	144	168.120	169	152.860	194	140.752
20	487.393	45	325.488	70	255.299	95	214.467	120	187.193	145	167.432	170	152.323	195	140.319
21	476.633	46	321.679	71	253.266	96	213.173	121	186.284	146	166.752	171	151.791	196	139.889
22	466.472	47	317.984	72	251.275	97	211.899	122	185.386	147	166.079	172	151.263	197	139.462
23	456.856	48	314.398	73	249.325	98	210.645	123	184.500	148	165.412	173	150.741	198	139.039
24	447.740	49	310.915	74	247.413	99	209.410	124	183.624	149	164.753	174	150.223	199	138.619
25	439.084	50	307.531	75	245.539	100	208.194	125	182.760	150	164.101	175	149.709	200	138.203

P=50 (年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	1097.569	26	453.929	51	323.075	76	260.636	101	222.695	126	196.681	151	177.494	176	162.627
2	1016.952	27	445.791	52	319.776	77	258.776	102	221.473	127	195.805	152	176.828	177	162.100
3	950.496	28	438.034	53	316.567	78	256.951	103	220.269	128	194.939	153	176.169	178	161.578
4	894.551	29	430.629	54	313.442	79	255.160	104	219.082	129	194.083	154	175.516	179	161.061
5	846.655	30	423.551	55	310.399	80	253.402	105	217.913	130	193.237	155	174.870	180	160.547
6	805.079	31	416.777	56	307.434	81	251.677	106	216.760	131	192.401	156	174.230	181	160.038
7	768.569	32	410.287	57	304.544	82	249.982	107	215.623	132	191.575	157	173.597	182	159.534
8	736.192	33	404.061	58	301.726	83	248.318	108	214.502	133	190.758	158	172.969	183	159.033
9	707.236	34	398.083	59	298.976	84	246.683	109	213.397	134	189.951	159	172.348	184	158.537
10	681.150	35	392.336	60	296.293	85	245.077	110	212.307	135	189.152	160	171.733	185	158.045
11	657.497	36	386.807	61	293.674	86	243.499	111	211.231	136	188.363	161	171.123	186	157.557
12	635.929	37	381.483	62	291.116	87	241.948	112	210.171	137	187.582	162	170.519	187	157.073
13	616.162	38	376.351	63	288.617	88	240.423	113	209.124	138	186.810	163	169.921	188	156.594
14	597.964	39	371.400	64	286.175	89	238.923	114	208.091	139	186.047	164	169.329	189	156.118
15	581.141	40	366.620	65	283.787	90	237.449	115	207.072	140	185.291	165	168.742	190	155.645
16	565.532	41	362.002	66	281.452	91	235.998	116	206.066	141	184.544	166	168.160	191	155.177
17	551.000	42	357.538	67	279.169	92	234.571	117	205.073	142	183.805	167	167.584	192	154.713
18	537.430	43	353.218	68	276.934	93	233.167	118	204.093	143	183.074	168	167.013	193	154.252
19	524.722	44	349.035	69	274.747	94	231.786	119	203.126	144	182.351	169	166.448	194	153.795
20	512.791	45	344.983	70	272.605	95	230.426	120	202.170	145	181.635	170	165.887	195	153.341
21	501.561	46	341.055	71	270.508	96	229.087	121	201.227	146	180.927	171	165.332	196	152.891
22	490.968	47	337.245	72	268.453	97	227.769	122	200.295	147	180.226	172	164.781	197	152.445
23	480.956	48	333.547	73	266.440	98	226.472	123	199.375	148	179.532	173	164.235	198	152.002
24	471.474	49	329.956	74	264.467	99	225.194	124	198.466	149	178.846	174	163.695	199	151.562
25	462.478	50	326.467	75	262.533	100	223.935	125	197.568	150	178.166	175	163.159	200	151.126

P=100(年)

t: 分钟; q: 升/秒/公顷

t	q	t	q	t	q	t	q	t	q	t	q	t	q	t	q
1	1204.597	26	481.395	51	346.350	76	282.044	101	242.843	126	215.858	151	195.875	176	180.333
2	1104.843	27	472.958	52	342.955	77	280.125	102	241.578	127	214.947	152	195.180	177	179.781
3	1025.222	28	464.921	53	339.651	78	278.242	103	240.331	128	214.047	153	194.492	178	179.234
4	959.824	29	457.255	54	336.435	79	276.394	104	239.102	129	213.157	154	193.810	179	178.691
5	904.903	30	449.933	55	333.303	80	274.580	105	237.890	130	212.277	155	193.136	180	178.154
6	857.958	31	442.930	56	330.251	81	272.800	106	236.696	131	211.407	156	192.468	181	177.620
7	817.250	32	436.224	57	327.276	82	271.051	107	235.518	132	210.548	157	191.806	182	177.091
8	781.523	33	429.794	58	324.375	83	269.333	108	234.356	133	209.698	158	191.150	183	176.567
9	749.849	34	423.623	59	321.545	84	267.645	109	233.210	134	208.857	159	190.501	184	176.047
10	721.524	35	417.693	60	318.783	85	265.986	110	232.080	135	208.026	160	189.858	185	175.531
11	696.003	36	411.990	61	316.086	86	264.356	111	230.965	136	207.204	161	189.221	186	175.019
12	672.858	37	406.500	62	313.452	87	262.754	112	229.865	137	206.391	162	188.590	187	174.511
13	651.745	38	401.209	63	310.878	88	261.178	113	228.779	138	205.587	163	187.965	188	174.008
14	632.387	39	396.107	64	308.363	89	259.629	114	227.708	139	204.792	164	187.346	189	173.509
15	614.557	40	391.182	65	305.904	90	258.105	115	226.650	140	204.005	165	186.732	190	173.013
16	598.067	41	386.425	66	303.499	91	256.605	116	225.606	141	203.227	166	186.124	191	172.522
17	582.757	42	381.827	67	301.147	92	255.130	117	224.576	142	202.457	167	185.521	192	172.034
18	568.496	43	377.378	68	298.844	93	253.679	118	223.558	143	201.695	168	184.924	193	171.550
19	555.171	44	373.072	69	296.590	94	252.250	119	222.554	144	200.941	169	184.332	194	171.070
20	542.684	45	368.900	70	294.383	95	250.844	120	221.562	145	200.194	170	183.746	195	170.594
21	530.953	46	364.856	71	292.222	96	249.459	121	220.582	146	199.456	171	183.164	196	170.122
22	519.905	47	360.934	72	290.104	97	248.095	122	219.614	147	198.725	172	182.588	197	169.653
23	509.478	48	357.128	73	288.029	98	246.753	123	218.658	148	198.002	173	182.017	198	169.187
24	499.615	49	353.432	74	285.995	99	245.430	124	217.713	149	197.285	174	181.450	199	168.726
25	490.268	50	349.841	75	284.000	100	244.127	125	216.780	150	196.576	175	180.889	200	168.267