GAS TABLES

International Version

THERMODYNAMIC PROPERTIES OF AIR
PRODUCTS OF COMBUSTION
AND
COMPONENT GASES
COMPRESSIBLE FLOW FUNCTIONS

Including those of Ascher H. Shapiro
and Gilbert M. Edelman

SECOND EDITION
(SI UNITS)

BY

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GAS TABLES

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Gas Tables
BY J. H. KEENAN AND F. G. KEYES
Mollier Chart
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Steam Tables
BY G. N. HATSOPOULOS AND J. H. KEENAN
Principles of General Thermodynamics

IN MEMORIAM
Joseph H. Keenan

Professor Joseph H. Keenan, who was the motivating force behind these tables from the beginning, died at the age of 77 on July 17, 1977. Although his health gradually declined during the last two years of his life, he remained active and managed to complete the preliminary arrangements which eventually led to the publication of the two versions of the second edition.

As coauthor, Dr. Jing Chao shouldered a greater share of the responsibility for the 1980 revision in English Units and for the most recent tables in SI Units. His son, William C. H. Chao, played a crucial role in devising the computer program which made possible a calculation of the values and the tabulation of them automatically for the printed page. Other individuals, including many who had been friends of Professor Keenan, were more than generous with their assistance. Dr. George N. Hatsopoulos in particular never failed to provide the benefits of his judgement and his technical talents.

The origins of these tables date back more than 30 years to a collaboration between Professor Keenan and Professor Joseph Kaye, who died in 1961. They developed the basic concepts and methodology used in formulating much of the data for the early editions. For this reason it was considered appropriate here to include their acknowledgments and the contents of each preface from the 1945 and 1948 printings. The wives of these men deserve recognition as well—Mrs. Ida Kaye for her understanding cooperation and Mrs. Isabel M. Keenan for her encouragement and support.

I know that my father would have wanted me to thank on his behalf all of the people who contributed their time and effort in making the revisions a success. I know too how deeply he would have appreciated the readiness and willingness shown by those among them who knew him and were close to him.

MATTHEW A. KEENAN

Belmont, Massachusetts
February 1983

PREFACE TO THE SECOND EDITION OF THE GAS TABLES IN SI UNITS

When the authors decided to embark upon a revision of the *Gas Tables*, they planned to publish a new edition using English Units as before and then to follow it later with another edition of these tables converted into International Units.

Professor Joseph H. Keenan directed the initial preparations, but died in 1977 before he could participate further in the project. After the unfortunate loss of his presence, it wasn't until 1980 that the revised *Gas Tables* in English Units (second edition) reached a successful conclusion. Now the final half of the overall project has become a reality with the arrival of these revised tables in International Units.

In this latest edition, the sources of data, methods of calculation, and formats for tabulating the evaluated results were the same as before. The property values given in Tables 1 through 24 were reevaluated at selected temperatures in Kelvin (K) and at P = 101.325 kPa (1 atm.). The explanatory text for "Sources of Data and Methods of Calculation," and for the chapter on "Examples," were essentially unchanged with minimum adjustment for employing different units for recalculation.

To provide the corrected entropy at 1 bar pressure for thermodynamic calculations, the constant 0.1094 JK^{-1} mol^{-1} should be added to each entropy value listed in Tables 3, 5, 7, 11, 13, 15, 17, 19 and 21. In computing entropy change for a constant pressure process the listed entropy values can be used without corrections, because the same constants added to both quantities cancel each other.

The entropy values presented in Table 1 should be augmented by 4.7767 JK^{-1} mol^{-1} to yield the corrected entropy for one kilogram at one bar pressure. This correction is not necessary for calculations of entropy changes at constant pressures.

SI is the official abbreviation for the International System of Units (Le Systeme International d'Unites). It is a rationalization of the cgs and MKS systems. The seven base units of meter (m), kilogram (kg), second (s), Kelvin (K), mole (mol), ampere (A), and candela (cd) correspond respectively to length, mass, time, temperature, amount of substance, electric current, and luminous intensity. Obtained therefrom are other derived and supplementary units. Some allowable units, not a part of SI, may also be used in conjunction with SI.

SI was adopted by the General Conference of Weights and Measures in 1960 as recommended units for use in Science and Technology. In 1964 the National Bureau of Standards adopted SI for use by its staff and issued a statement interpreting this policy in 1968. In recent years, scientific and technical communities in the United States also accepted the mandatory application of SI in all publications and all papers presented at national meetings.

The publication of this most recent edition of *Gas Tables* would not have been possible without the invaluable cooperation of numerous individuals. Throughout much of the undertaking, it was reassuring to have available the experienced counsel of Dr. George N. Hatsopoulos, who enjoyed a long association and close friendship with the late Professor Keenan. Another friend and colleague of the professor was Dr. Elias P. Gyftopoulos, whose helpful advice was required on several occasions. And the professor's son, Matthew A. Keenan, lent his support by coordinating the various phases of the project and by editing the manuscript.

A key contributor was my son, William C. H. Chao, who brought his knowledge of computers to the considerable task of recalculating the revised numerical tables and to the direct generation of photocomposition tapes, thereby automating the printing of the tables and eliminating the potential for typesetting errors. Sincere gratitude also belongs to the people at Inforonics, Inc., for their kind services and efficient handling of the photocomposition galleys.

The author particularly wishes to thank Dr. Lester Haar at the National Bureau of Standards for recommending that Dr. Harold W. Wooley's recently reevaluated values of ideal gas thermodynamic properties for steam be adopted in this book. I am also grateful to David T. Barr for reworking in detail the illustrative problems in the chapter on "Examples."

On behalf of all the participants, it is hoped that Professor Keenan would have been pleased with the published results and have considered them worthy of the high standards he maintained throughout a long and productive career in the field of thermodynamics.

Finally, any comments or observations that are forwarded by the reader of this revision will be greatly appreciated.

JING CHAO

College Station, Texas
February 1983

PREFACE TO THE FIRST EDITION OF THE GAS TABLES

THIS book supersedes a previous one entitled *Thermodynamic Properties of Air*. The properties of air have been reexamined and recalculated, the properties of products of combustion of hydrocarbons and of the constituent gases have been added, and tables of functions useful in analysis of the flow of compressible fluids have been greatly extended.

All values of the thermodynamic properties in this book are based on the examination of data from spectroscopic sources which was published by F. D. Rossini and his coworkers of the National Bureau of Standards in 1945. This was a revision of the calculated values of Johnston, Giauque, Gordon, and Kassel, and of the tabular values of Heck. The revision consisted mainly of application of new values of the fundamental constants.

The present status of these thermodynamic properties is relatively satisfactory. The uncertainties remaining in the interpretation of spectra appear to be small for monatomic and diatomic gases, and of no great order for CO_2 and H_2O. For engineering application to the design of power apparatus the precision of the present tables is of the same order as that of modern steam tables. The convenience is of a higher order.

The base temperature, for which enthalpy is zero, is not the same here as in *Thermodynamic Properties of Air*. It is taken to be zero on the absolute Fahrenheit scale in accordance with the data of Rossini. Negative values of properties are thereby avoided.

The molal unit is employed for all tables of thermodynamic properties except air. As compared with the mass unit, the molal unit makes the range of values between tables very much smaller. It also permits the use of a single table for the products of combustion corresponding to a wide range of carbon-hydrogen ratios, provided only that the "percentage of theoretical air" is held fixed. Certain other interpretations of the same table in terms of mixtures of air and fuel vapor and of air and water vapor are also valid to good precision.

Although the major tables of thermodynamic properties can be used in the analysis of the flow of compressible fluids, several excellent tabulations which have recently appeared are of greater specific convenience. The more generally useful of these have been included here. Some of the most valuable portions of this material prepared by Ascher H. Shapiro and Gilbert M. Edelman have not been previously published except in reports of limited circulation.

Dependable values of viscosity and thermal conductivity for air cover a limited range of temperature—for other gases an entirely inadequate range. Values of these properties are tabulated here only for air. Correlation of existing data and some measurements to obtain new data are in progress for other gases. As the results of this work become available they will be incorporated into the tables. The scope of the investigations in progress, however, is entirely too limited to fill the urgent need for knowledge of these two properties.

JOSEPH H. KEENAN
JOSEPH KAYE

Cambridge, May 1948

PREFACE TO THERMODYNAMIC PROPERTIES OF AIR

THE need for a working table of the thermodynamic properties of air has been emphasized recently by the rapidly growing interest in the gas turbine. The compression of atmospheric air which occurs in a gas turbine can be computed with reasonable convenience without the aid of a table. Computations of certain other processes, however—such as the heating of air in a regenerator or the expansion of air and similar gases from states of high temperature—involve laborious integrations if tabulated properties are not available.

For such computations air may be considered to be a relatively simple substance because the expression

$$pv = RT$$

is an adequate equation of state. By virtue of this fact the table of properties for air is simpler than the corresponding tables for vapors in that a single independent argument serves in place of two. Within the same space, therefore, a far more detailed table is possible for air than for steam. In the present table, as contrasted with existing tables for vapors, interpolation can often be dispensed with, and where it must be used it is a single interpolation which may be done by inspection.

Since the value of the gas constant R is known with great precision, the degree of uncertainty in the properties tabulated here depends only upon the state of knowledge of specific heats. The development of spectroscopic methods of determining the specific heats of the simpler gases at zero pressure has reduced this degree of uncertainty to such an extent that there is now little room for disagreement. In general, the effects of departures in composition and in pressure from those stipulated for this table will be greater than the effects of uncertainties in the data upon which the table is based. For this good fortune we are indebted to those who have labored to perfect our knowledge of the specific heats of gases.

Table 1 appeared in an abbreviated form in the *Journal of Applied Mechanics*. Since that publication the composition assumed and the values of the specific heat for air have been revised, and the entire table has been recomputed, interpolated to smaller intervals, and extended to higher temperatures.

In addition to the usual thermodynamic properties, values are given for viscosity, thermal conductivity, and Prandtl number because of their great utility in engineering computations. Certain commonly used functions of the pressure ratio are also given in some detail for a range of values of the polytropic exponent.

The present data will satisfy all but the most exacting requirements for calculations of gas-turbine processes. In order to satisfy certain other requirements work is in progress on the extension of the present data to cover the properties of air-fuel mixtures for hydrocarbon fuels and their products of combustion.

JOSEPH H. KEENAN
JOSEPH KAYE

Cambridge, March 1945

CONTENTS

SYMBOLS AND UNITS FOR TABLES 1 TO 8

a velocity of sound $= \sqrt{kRT}$, m s^{-1}
c_p specific heat at constant pressure, J K^{-1} kg^{-1}
c_v specific heat at constant volume, J K^{-1} kg^{-1}
G flow per unit area or mass velocity, kg m^{-2} s^{-1}
h enthalpy per unit mass, kJ kg^{-1}*
$\bar{h}$ enthalpy per mole, J g-mol^{-1}
k c_p/c_v
p pressure, kPa
Pr Prandtl number $= c_p u/\lambda$
p_r relative pressure†
R gas constant for air $= 0.287031$ kJ K^{-1} kg^{-1}
T temperature, K
t temperature, °C
u internal energy per unit mass, kJ kg^{-1}
$\bar{u}$ internal energy per mole, J g-mol^{-1}
v_r relative volume†
λ thermal conductivity, W m^{-1} K^{-1}
μ viscosity, NR m^{-2}
ϕ $\int_{T_0}^{T} c_p \, dT$, kJ K^{-1} kg^{-1}
$\bar{\phi}$ $\int_{T_0}^{T} \frac{\bar{c}_p}{T} \, dT$, J K^{-1} g-mol^{-1}‡

*To obtain values in Joules per gram-mole multiply tabulated values by molecular weight of air, namely 28.9669.

†The ratio of the pressures p_a and p_b corresponding to the temperatures T_a and T_b, respectively, along a given isentropic is equal to the ratio of the relative pressures p_{ra} and p_{rb} as tabulated for T_a and T_b, respectively. Thus

$$\left(\frac{p_a}{p_b}\right)_{s=\text{constant}} = \frac{p_{ra}}{p_{rb}}$$

Similarly

$$\left(\frac{v_a}{v_b}\right)_{s=\text{constant}} = \frac{v_{ra}}{v_{rb}}$$

‡For interpolation between Table 1 and Table 3 the value of ϕ from Table 1 should be augmented by unity and multiplied by the molecular weight of air, namely 28.9669. For interpolation between Table 1 and Table 3 the value of V_r from Table 1 should be multiplied by 0.0289669.

Table 1 Air at Low Pressures (for One Kilogram)

T	t	h	p_r	u	v_r	ϕ
100	−173.15	99.93	.02977	71.23	964.19	4.6004
101		100.93	.03082	71.94	940.59	4.6104
102		101.93	.03190	72.66	917.79	4.6203
103		102.94	.03300	73.37	895.76	4.6300
104		103.94	.03414	74.09	874.46	4.6397
105	−168.15	104.94	.03530	74.80	853.86	4.6493
106		105.94	.03648	75.52	833.94	4.6588
107		106.94	.03770	76.23	814.66	4.6682
108		107.94	.03894	76.95	796.00	4.6775
109		108.95	.04022	77.66	777.94	4.6868
110	−163.15	109.95	.04152	78.38	760.44	4.6959
111		110.95	.04285	79.09	743.49	4.7050
112		111.95	.04422	79.81	727.07	4.7140
113		112.95	.04561	80.52	711.15	4.7229
114		113.96	.04703	81.23	695.71	4.7317
115	−158.15	114.96	.04849	81.95	680.74	4.7405
116		115.96	.04998	82.66	666.22	4.7491
117		116.96	.05150	83.38	652.13	4.7577
118		117.96	.05305	84.09	638.45	4.7663
119		118.97	.05464	84.81	625.17	4.7747
120	−153.15	119.97	.05626	85.52	612.27	4.7831
121		120.97	.05791	86.24	599.75	4.7914
122		121.97	.05960	86.95	587.58	4.7997
123		122.97	.06132	87.67	575.75	4.8078
124		123.98	.06308	88.38	564.26	4.8160
125	−148.15	124.98	.06487	89.10	553.08	4.8240
126		125.98	.06670	89.81	542.21	4.8320
127		126.98	.06857	90.53	531.64	4.8399
128		127.98	.07047	91.24	521.35	4.8478
129		128.99	.07241	91.96	511.35	4.8556
130	−143.15	129.99	.07439	92.67	501.60	4.8633
131		130.99	.07641	93.39	492.12	4.8710
132		131.99	.07846	94.10	482.89	4.8786
133		132.99	.08056	94.82	473.89	4.8862
134		134.00	.08269	95.53	465.13	4.8937
135	−138.15	135.00	.08486	96.25	456.60	4.9011
136		136.00	.08708	96.96	448.28	4.9085
137		137.00	.08934	97.68	440.18	4.9159
138		138.00	.09163	98.39	432.27	4.9231
139		139.01	.09397	99.11	424.57	4.9304
140	−133.15	140.01	.09635	99.82	417.06	4.9376
141		141.01	.09878	100.54	409.73	4.9447
142		142.01	.10124	101.25	402.58	4.9518
143		143.01	.10375	101.97	395.60	4.9588
144		144.02	.10631	102.68	388.79	4.9658
145	−128.15	145.02	.10891	103.40	382.15	4.9727
146		146.02	.11155	104.11	375.66	4.9796
147		147.02	.11424	104.83	369.33	4.9864
148		148.02	.11698	105.54	363.15	4.9932
149		149.03	.11976	106.26	357.11	5.0000
150	−123.15	150.03	.12259	106.97	351.20	5.0067
151		151.03	.12547	107.69	345.44	5.0133
152		152.03	.12839	108.40	339.81	5.0200
153		153.03	.13137	109.12	334.30	5.0265
154		154.04	.13439	109.83	328.92	5.0331
155	−118.15	155.04	.13746	110.55	323.66	5.0395
156		156.04	.14058	111.26	318.52	5.0460
157		157.04	.14375	111.98	313.49	5.0524
158		158.04	.14697	112.69	308.57	5.0588
159		159.05	.15025	113.41	303.76	5.0651
160	−113.15	160.05	.15357	114.12	299.05	5.0714
161		161.05	.15695	114.84	294.44	5.0776
162		162.05	.16038	115.55	289.94	5.0838
163		163.05	.16386	116.27	285.53	5.0900
164		164.06	.16740	116.98	281.21	5.0961
165	−108.15	165.06	.17099	117.70	276.98	5.1022
166		166.06	.17463	118.41	272.85	5.1082
167		167.06	.17833	119.13	268.79	5.1143
168		168.06	.18209	119.84	264.83	5.1202
169		169.07	.18590	120.56	260.94	5.1262
170	−103.15	170.07	.18977	121.27	257.13	5.1321
171		171.07	.19369	121.99	253.40	5.1380
172		172.07	.19768	122.70	249.75	5.1438
173		173.07	.20172	123.42	246.17	5.1496
174		174.08	.20582	124.13	242.66	5.1554
175	−98.15	175.08	.20998	124.85	239.22	5.1612
176		176.08	.21420	125.56	235.85	5.1669
177		177.08	.21847	126.28	232.54	5.1725
178		178.08	.22281	126.99	229.30	5.1782
179		179.09	.22721	127.71	226.12	5.1838
180	−93.15	180.09	.23168	128.42	223.01	5.1894
181		181.09	.23620	129.14	219.95	5.1949
182		182.09	.24079	129.85	216.95	5.2005
183		183.09	.24544	130.57	214.01	5.2059
184		184.10	.25015	131.28	211.13	5.2114
185	−88.15	185.10	.25493	132.00	208.29	5.2168
186		186.10	.25978	132.71	205.51	5.2222
187		187.10	.26468	133.43	202.79	5.2276
188		188.11	.26966	134.14	200.11	5.2330
189		189.11	.27470	134.86	197.48	5.2383
190	−83.15	190.11	.27981	135.57	194.90	5.2436
191		191.11	.28498	136.29	192.37	5.2488
192		192.11	.29023	137.00	189.89	5.2541
193		193.12	.29554	137.72	187.44	5.2593
194		194.12	.30092	138.43	185.05	5.2644
195	−78.15	195.12	.30637	139.15	182.69	5.2696
196		196.12	.31189	139.86	180.38	5.2747
197		197.12	.31748	140.58	178.11	5.2798
198		198.13	.32314	141.29	175.87	5.2849
199		199.13	.32888	142.01	173.68	5.2899

Table 1 Air at Low Pressures (for One Kilogram)

T	t	h	p_r	u	v_r	ϕ
200	−73.15	200.13	.33468	142.72	171.52	5.2950
201		201.13	.34056	143.44	169.41	5.3000
202		202.13	.34652	144.15	167.32	5.3049
203		203.14	.35254	144.87	165.28	5.3099
204		204.14	.35864	145.58	163.27	5.3148
205	−68.15	205.14	.36482	146.30	161.29	5.3197
206		206.14	.37107	147.02	159.35	5.3246
207		207.15	.37740	147.73	157.43	5.3294
208		208.15	.38380	148.45	155.55	5.3343
209		209.15	.39029	149.16	153.71	5.3391
210	−63.15	210.15	.39684	149.88	151.89	5.3439
211		211.15	.40348	150.59	150.10	5.3486
212		212.16	.41020	151.31	148.34	5.3534
213		213.16	.41700	152.02	146.61	5.3581
214		214.16	.42387	152.74	144.91	5.3628
215	−58.15	215.16	.43083	153.45	143.24	5.3674
216		216.17	.43787	154.17	141.59	5.3721
217		217.17	.44499	154.88	139.97	5.3767
218		218.17	.45219	155.60	138.38	5.3813
219		219.17	.45947	156.31	136.81	5.3859
220	−53.15	220.18	.46684	157.03	135.26	5.3905
221		221.18	.47429	157.74	133.74	5.3950
222		222.18	.48183	158.46	132.25	5.3996
223		223.18	.48945	159.17	130.77	5.4041
224		224.18	.49716	159.89	129.32	5.4085
225	−48.15	225.19	.50495	160.61	127.90	5.4130
226		226.19	.51284	161.32	126.49	5.4175
227		227.19	.52080	162.04	125.11	5.4219
228		228.19	.52886	162.75	123.74	5.4263
229		229.20	.53701	163.47	122.40	5.4307
230	−43.15	230.20	.54524	164.18	121.08	5.4350
231		231.20	.55357	164.90	119.78	5.4394
232		232.20	.56198	165.61	118.49	5.4437
233		233.21	.57049	166.33	117.23	5.4480
234		234.21	.57908	167.04	115.99	5.4523
235	−38.15	235.21	.58777	167.76	114.76	5.4566
236		236.21	.59656	168.48	113.55	5.4609
237		237.22	.60543	169.19	112.36	5.4651
238		238.22	.61440	169.91	111.19	5.4693
239		239.22	.62347	170.62	110.03	5.4735
240	−33.15	240.22	.63263	171.34	108.89	5.4777
241		241.23	.64188	172.05	107.77	5.4819
242		242.23	.65123	172.77	106.66	5.4860
243		243.23	.66068	173.48	105.57	5.4902
244		244.24	.67023	174.20	104.50	5.4943
245	−28.15	245.24	.67987	174.92	103.44	5.4984
246		246.24	.68962	175.63	102.39	5.5025
247		247.24	.69946	176.35	101.36	5.5065
248		248.25	.70940	177.06	100.34	5.5106
249		249.25	.71945	177.78	99.34	5.5146
250	−23.15	250.25	.7296	178.49	98.353	5.5186
251		251.25	.7398	179.21	97.379	5.5226
252		252.26	.7502	179.93	96.418	5.5266
253		253.26	.7606	180.64	95.471	5.5306
254		254.26	.7712	181.36	94.536	5.5346
255	−18.15	255.27	.7819	182.07	93.614	5.5385
256		256.27	.7926	182.79	92.705	5.5424
257		257.27	.8035	183.51	91.808	5.5463
258		258.28	.8145	184.22	90.923	5.5502
259		259.28	.8256	184.94	90.049	5.5541
260	−13.15	260.28	.8368	185.65	89.188	5.5580
261		261.28	.8481	186.37	88.338	5.5618
262		262.29	.8595	187.09	87.499	5.5657
263		263.29	.8710	187.80	86.671	5.5695
264		264.29	.8826	188.52	85.855	5.5733
265	−8.15	265.30	.8944	189.23	85.049	5.5771
266		266.30	.9062	189.95	84.253	5.5809
267		267.30	.9182	190.67	83.468	5.5846
268		268.31	.9302	191.38	82.693	5.5884
269		269.31	.9424	192.10	81.928	5.5921
270	−3.15	270.31	.9547	192.81	81.173	5.5958
271		271.32	.9672	193.53	80.427	5.5996
272		272.32	.9797	194.25	79.691	5.6032
273		273.32	.9923	194.96	78.965	5.6069
274		274.33	1.0051	195.68	78.248	5.6106
275	1.85	275.33	1.0180	196.40	77.539	5.6143
276		276.33	1.0310	197.11	76.840	5.6179
277		277.34	1.0441	197.83	76.149	5.6215
278		278.34	1.0573	198.55	75.467	5.6251
279		279.34	1.0707	199.26	74.794	5.6287
280	6.85	280.35	1.0842	199.98	74.129	5.6323
281		281.35	1.0978	200.70	73.472	5.6359
282		282.36	1.1115	201.41	72.823	5.6395
283		283.36	1.1253	202.13	72.182	5.6430
284		284.36	1.1393	202.85	71.549	5.6466
285	11.85	285.37	1.1534	203.56	70.924	5.6501
286		286.37	1.1676	204.28	70.306	5.6536
287		287.37	1.1820	205.00	69.696	5.6571
288		288.38	1.1964	205.71	69.093	5.6606
289		289.38	1.2110	206.43	68.497	5.6641
290	16.85	290.39	1.2258	207.15	67.909	5.6676
291		291.39	1.2406	207.86	67.327	5.6710
292		292.40	1.2556	208.58	66.753	5.6745
293		293.40	1.2707	209.30	66.185	5.6779
294		294.40	1.2859	210.02	65.624	5.6813
295	21.85	295.41	1.3013	210.73	65.069	5.6847
296		296.41	1.3168	211.45	64.521	5.6881
297		297.42	1.3324	212.17	63.980	5.6915
298		298.42	1.3482	212.89	63.445	5.6949
299		299.43	1.3641	213.60	62.916	5.6983

Table 1 Air at Low Pressures (for One Kilogram)

T	t	h	p_r	u	v_r	ϕ
300	26.85	300.43	1.3801	214.32	62.393	5.7016
301		301.43	1.3963	215.04	61.876	5.7050
302		302.44	1.4126	215.76	61.365	5.7083
303		303.44	1.4290	216.47	60.860	5.7116
304		304.45	1.4456	217.19	60.360	5.7149
305	31.85	305.45	1.4623	217.91	59.867	5.7182
306		306.46	1.4792	218.63	59.379	5.7215
307		307.46	1.4962	219.34	58.896	5.7248
308		308.47	1.5133	220.06	58.419	5.7281
309		309.47	1.5306	220.78	57.947	5.7313
310	36.85	310.48	1.5480	221.50	57.481	5.7346
311		311.48	1.5655	222.22	57.020	5.7378
312		312.49	1.5832	222.93	56.564	5.7410
313		313.49	1.6011	223.65	56.112	5.7442
314		314.50	1.6191	224.37	55.666	5.7474
315	41.85	315.50	1.6372	225.09	55.225	5.7506
316		316.51	1.6555	225.81	54.789	5.7538
317		317.51	1.6739	226.53	54.357	5.7570
318		318.52	1.6925	227.24	53.930	5.7602
319		319.53	1.7112	227.96	53.508	5.7633
320	46.85	320.53	1.7301	228.68	53.091	5.7665
321		321.54	1.7491	229.40	52.677	5.7696
322		322.54	1.7682	230.12	52.269	5.7727
323		323.55	1.7876	230.84	51.865	5.7759
324		324.55	1.8070	231.56	51.465	5.7790
325	51.85	325.56	1.8267	232.27	51.069	5.7821
326		326.57	1.8464	232.99	50.677	5.7852
327		327.57	1.8664	233.71	50.290	5.7882
328		328.58	1.8864	234.43	49.907	5.7913
329		329.58	1.9067	235.15	49.528	5.7944
330	56.85	330.59	1.9271	235.87	49.152	5.7974
331		331.60	1.9476	236.59	48.781	5.8005
332		332.60	1.9683	237.31	48.414	5.8035
333		333.61	1.9892	238.03	48.050	5.8065
334		334.62	2.0102	238.75	47.690	5.8096
335	61.85	335.62	2.0314	239.47	47.334	5.8126
336		336.63	2.0528	240.19	46.982	5.8156
337		337.64	2.0743	240.91	46.633	5.8186
338		338.64	2.0959	241.63	46.288	5.8215
339		339.65	2.1178	242.35	45.946	5.8245
340	66.85	340.66	2.1398	243.07	45.608	5.8275
341		341.66	2.1619	243.79	45.273	5.8304
342		342.67	2.1843	244.51	44.942	5.8334
343		343.68	2.2068	245.23	44.614	5.8363
344		344.69	2.2294	245.95	44.289	5.8393
345	71.85	345.69	2.2523	246.67	43.967	5.8422
346		346.70	2.2753	247.39	43.649	5.8451
347		347.71	2.2984	248.11	43.334	5.8480
348		348.72	2.3218	248.83	43.022	5.8509
349		349.72	2.3453	249.55	42.713	5.8538
350	76.85	350.73	2.3689	250.27	42.407	5.8567
351		351.74	2.3928	250.99	42.105	5.8596
352		352.75	2.4168	251.71	41.805	5.8624
353		353.76	2.4410	252.43	41.508	5.8653
354		354.76	2.4654	253.16	41.214	5.8681
355	81.85	355.77	2.4900	253.88	40.923	5.8710
356		356.78	2.5147	254.60	40.635	5.8738
357		357.79	2.5396	255.32	40.349	5.8767
358		358.80	2.5647	256.04	40.067	5.8795
359		359.81	2.5899	256.76	39.787	5.8823
360	86.85	360.81	2.6154	257.48	39.509	5.8851
361		361.82	2.6410	258.21	39.235	5.8879
362		362.83	2.6668	258.93	38.963	5.8907
363		363.84	2.6928	259.65	38.693	5.8935
364		364.85	2.7190	260.37	38.426	5.8962
365	91.85	365.86	2.7453	261.09	38.162	5.8990
366		366.87	2.7718	261.82	37.900	5.9018
367		367.88	2.7986	262.54	37.641	5.9045
368		368.89	2.8255	263.26	37.384	5.9073
369		369.90	2.8526	263.98	37.129	5.9100
370	96.85	370.91	2.8799	264.71	36.877	5.9127
371		371.92	2.9073	265.43	36.628	5.9155
372		372.93	2.9350	266.15	36.380	5.9182
373		373.94	2.9629	266.87	36.135	5.9209
374		374.95	2.9909	267.60	35.892	5.9236
375	101.85	375.96	3.0191	268.32	35.651	5.9263
376		376.97	3.0476	269.04	35.413	5.9290
377		377.98	3.0762	269.77	35.177	5.9317
378		378.99	3.1050	270.49	34.943	5.9344
379		380.00	3.1340	271.21	34.711	5.9370
380	106.85	381.01	3.1633	271.94	34.481	5.9397
381		382.02	3.1927	272.66	34.253	5.9423
382		383.03	3.2223	273.39	34.027	5.9450
383		384.04	3.2521	274.11	33.804	5.9476
384		385.05	3.2821	274.83	33.582	5.9503
385	111.85	386.06	3.3123	275.56	33.362	5.9529
386		387.08	3.3427	276.28	33.145	5.9555
387		388.09	3.3733	277.01	32.929	5.9581
388		389.10	3.4042	277.73	32.715	5.9608
389		390.11	3.4352	278.46	32.503	5.9634
390	116.85	391.12	3.4664	279.18	32.293	5.9660
391		392.13	3.4979	279.91	32.085	5.9685
392		393.15	3.5295	280.63	31.879	5.9711
393		394.16	3.5614	281.36	31.674	5.9737
394		395.17	3.5934	282.08	31.471	5.9763
395	121.85	396.18	3.6257	282.81	31.270	5.9788
396		397.20	3.6582	283.53	31.071	5.9814
397		398.21	3.6909	284.26	30.874	5.9840
398		399.22	3.7238	284.98	30.678	5.9865
399		400.23	3.7569	285.71	30.484	5.9891