

BEYOND

SMART CITIES

CERTIFIED INDUSTRIAL ENERGY PROFESSIONAL

CIEP TRAINING PROGRAM

FOR INDUSTRIAL ENERGY SPECIALISTS

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

ENERGY SPECIALIST CURRICULUM

CERTIFIED INDUSTRIAL ENERGY SPECIALIST

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BEYOND

SMART CITIES

BOILER AND STEAM SYSTEMS - 2

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WHAT SHOULD YOU LEARN



Water Tube, Fire Tube, and Condensing Boilers

Saturated & Superheated Steam

Estimate Combustion Efficiency

Calculate Heat Flows & Enthalpy Values using Steam Tables

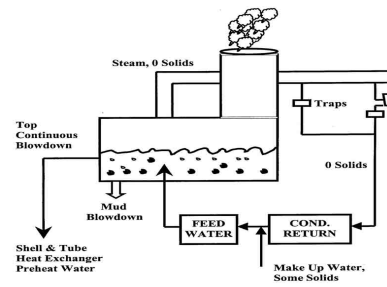
Energy Savings: Blowdown Heat Recovery, Flash Steam Utilization, Economisers, & Air Preheating

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BOILER BLOWDOWN



BOILER BLOWDOWN +

To cure these problems, boilers will have to be “blown down” in some fashion.

There is usually a top blowdown (skimming) that is often continuous or could easily be automated by blowing down when the conductivity of the water reaches a certain level. This top blowdown is relatively clean and usually a small volume flow. I

f the boiler is producing 700 kPa steam, then this blowdown is saturated water at 165 C

BOILER BLOWDOWN +

Thus, TOP BLOWDOWN IS AN EXCELLENT OPPORTUNITY FOR WASTE HEAT RECOVERY.

The bottom or mud blowdown is usually done manually, by timers, or automatically. To be sure the mud is adequately removed, this blowdown is usually drawn off in a large line with agitation. Mud blowdown is usually not a good candidate for heat recovery.

BOILER BLOWDOWN + (SEE FIGURE)



Purpose: Avoid "mud" build up in boiler

Problem: Very hot liquid at boiler drum pressure is rejected

Management:

- ☒ Maintain proper BD rate
- ☒ Recover heat from blowdown with a shell & tube heat exchanger (continuous or top blowdown)
- ☒ Recover flash steam (see heat recovery Q-8)



CALCULATING BOILER BLOWDOWN



$$\% \text{ BD} = \frac{A}{B - A} \times 100$$

A = ppm impurities in feedwater

B = ppm allowed in boiler



BOILER BLOWDOWN EXAMPLE



Calculate the percentage of blowdown for a boiler that has an allowable limit of 500 ppm of impurities and uses feedwater with 10 ppm of impurities.

A = 10 ppm
B = 500 ppm

$$\% \text{BD} = \frac{10}{500 - 10} \times 100 = 2\%$$



FLASH STEAM

When a hot pressurized liquid is placed in a tank with lower pressure, some “flash steam” will form as the enthalpy of the saturated liquid is reduced.

This phenomenon is sometimes a major loss to the steam system (700 kPa blowdown going to an unpressurized vessel will produce significant atmospheric pressure steam which is worthless and thus is a loss).

It is easy to calculate how much as shown in the example following.



FLASH STEAM +

Alternatively, the high-pressure liquid can be taken to a low pressure tank. The flash steam now has enough pressure to use, and inexpensive low-pressure steam is the result.

The next example shows how to calculate that. Continuous top blowdown is an excellent source for this purpose and sometimes enough pressure is left in the condensate return to accomplish the same thing.

An excellent system takes the high pressure blowdown, develops low pressure steam in the tank described and then runs the liquid left in the low pressure tank through a shell and tube heat exchanger to preheat the make up water. These systems are available commercially.



BLOWDOWN CALCULATION EXAMPLE

Calculate the % of flash steam generated by expanding saturated liquid from 10 bar to 2 bar.

From steam tables:

$H_{f1} = 762.5 \text{ kJ/kg}$ (10 bar liquid) $H_{f2} = 504.7 \text{ kJ/kg}$ (2 bar liquid) $H_{fg2} = 2201.5 \text{ kJ/kg}$ (2 bar liquid to vapor)

$$\% \text{ FLASH} = \frac{762.5 - 504.7}{2201.5} \times 100 = 11.7\%$$



BOILER LOG SHEETS



As with any other operating equipment, log sheets are extremely important.

They will tell you what is happening, what is going wrong, and usually what is causing that. It is vitally important to keep good log sheets for all boiler systems.

The numbers are usually taken or observed anyway. The log sheet is simply an organized method of keeping those numbers.

Log sheets should be developed for individual sites, boilers, and operators.

BOILER AND STEAM PLANT ECM'S



INCREASE BOILER EFFICIENCY

- 1.Reduce Excess Air to Boiler(s)
- 2.Provide Sufficient Air to Boiler(s) for Complete Combustion
- 3.Install Low Excess Air Burner (s)
- 4.Repair/Replace Faulty Burner (s)
- 5.Repair Natural Draft Burner(s) with Forced Draft Burner(s)
6. Install Turbulators in Firetube Boiler(s)
- 7.Replace Existing Boiler(s) with New More Efficient Boiler(s)
- 8.Install a Condensing Boiler/Water Heater
- 9.Install a Pulse Combustion Boiler/Water Heater
- 10.Install a Small Boiler for Summer Operation
- 11.Clean Boiler(s) to Eliminate Fouling and Scale
- 12.Improve Feedwater Chemical Treatment to Reduce Scaling
- 13.Optimize Boiler Loading When Using Multiple Boilers

BOILER AND STEAM PLANT ECM'S +



INSULATION

- 14.Install Insulation on Steam Line(s)
- 15.Install Insulation Jacket on Steam Fitting(s)
- 16.Install Insulation on Feedwater Line(s)
- 17.Install Insulation on Condensate Return Line(s)
- 18.Install Insulation on Condensate/Feedwater/Deaerator Tank(s)
- 19.Install Insulation on (Domestic) Hot Water Line(s)
- 20.Install Insulation on (Domestic) Hot Water Tank
21. Install Insulation Jacket on Boiler Shell
- 22.Install Insulation to Reduce Heat Loss

REDUCE BOILER LOAD

- 23.Repair Steam Leak(s)
- 24.Repair Failed Steam Trap(s)
- 25.Reduce Boiler Blowdown
- 26.Return Condensate to Boiler(s)

BOILER AND STEAM PLANT ECM'S +



REDUCE BOILER LOAD

23. Repair Steam Leak(s)
24. Repair Failed Steam Trap(s)
25. Reduce Boiler Blowdown
26. Return Condensate to Boiler(s)
27. Shut Off Steam Tracer(s) During Summer
28. Shut Off or Turn Back Boiler During Long Periods of No Use
29. Change Boiler Steam Pressure
30. Replace Continuous Gas Pilot(s) with Electronic Pilot(s)
31. Install Stack Damper(s) to Reduce Natural Draft Heat Loss
32. Pressurize Condensate Return System
33. Reduce or Utilize Flash Steam
34. Reduce Boiler Load and/or Steam Requirement



BOILER AND STEAM PLANT ECM'S +



WASTE HEAT RECOVERY

35. Install an Economizer to Preheat Boiler Feedwater
36. Install Heat Exchanger to Preheat Boiler Makeup or Feedwater
37. Install Heat Exchanger to Recover Blowdown Heat
38. Install Recuperator to Preheat Combustion Air
39. Recover Waste Heat to Supplement (Domestic) Hot Water Demand
40. Recover Heat from Boiler Flue Gas to Supplement Bldg Heat
41. Install Heat Recovery Steam Generator on Incinerator
42. Direct Contact Condensation Heat Recovery



BOILER AND STEAM PLANT ECM'S +



OTHERS

43. Vary (Domestic or Heating) Hot Water Temp. Based on Demand
44. Eliminate Air Conditioning in Boiler Room
45. Install Back Pressure Steam Turbine for Cogeneration
46. Switch to an interruptible Natural Gas Source
47. Request Change to a Different Utility Rate Schedule
48. Switch to a More Economical Fuel Source
49. Install Heat Pump to Supplement (Domestic) Hot Water Demand
50. Replace Electric Boiler(s) with Natural Gas Fired Boiler(s)
51. Install a Satellite Boiler
52. Install a Variable Frequency Drive on Pump(s) and Fan(s)
53. Replace On/Off Control System with Variable Firing Rate



SI STEAM TABLES

Table 2-1 SI Thermodynamic Properties of Water

Temp. t, °C	Absolute Pressure, P, MPa	Specific Volume, m ³ /kg			Enthalpy, kJ/kg			Temp., t, °C
		Sat. Liquid v _f , /g	Evap. v _{fg} , /g	Sat. Vapor v _g , /g	Sat. Liquid h _f , /g	Evap. h _{fg} , /g	Sat. Vapor h _g , /g	
-40	0.00101	0.001002	9001.00	9002.00	-40.00	176.20	136.20	-40
-30	0.00124	0.001002	7081.00	7082.00	-44.76	176.46	131.72	-30
-20	0.00147	0.001002	5021.17	5022.17	-48.93	176.67	127.74	-20
-10	0.00169	0.001002	3489.19	3490.19	-52.66	176.84	125.18	-10
0	0.00191	0.001002	2406.97	2407.97	-56.06	176.97	123.91	0
5	0.00207	0.001002	1944.01	1945.01	-48.39	177.12	124.73	5
10	0.00223	0.001002	1606.19	1607.19	-43.57	177.22	125.65	10
15	0.00239	0.001002	1346.19	1347.19	-39.29	177.29	126.59	15
20	0.00255	0.001002	1136.19	1137.19	-35.44	177.34	127.50	20
25	0.00271	0.001002	994.19	995.19	-32.01	177.37	128.38	25
30	0.00287	0.001002	874.19	875.19	-28.93	177.39	129.24	30
35	0.00303	0.001002	774.19	775.19	-26.19	177.40	130.07	35
40	0.00319	0.001002	689.19	690.19	-23.74	177.40	130.88	40
45	0.00335	0.001002	616.19	617.19	-21.56	177.40	131.67	45
50	0.00351	0.001002	552.19	553.19	-19.61	177.40	132.44	50
55	0.00367	0.001002	495.19	496.19	-17.86	177.40	133.19	55
60	0.00383	0.001002	444.19	445.19	-16.30	177.40	133.92	60
65	0.00399	0.001002	398.19	399.19	-14.91	177.40	134.63	65
70	0.00415	0.001002	356.19	357.19	-13.67	177.40	135.32	70
75	0.00431	0.001002	318.19	319.19	-12.57	177.40	135.99	75
80	0.00447	0.001002	284.19	285.19	-11.59	177.40	136.64	80
85	0.00463	0.001002	253.19	254.19	-10.72	177.40	137.27	85
90	0.00479	0.001002	225.19	226.19	-9.95	177.40	137.88	90
95	0.00495	0.001002	199.19	200.19	-9.27	177.40	138.47	95
100	0.00511	0.001002	176.19	177.19	-8.67	177.40	139.04	100
105	0.00527	0.001002	155.19	156.19	-8.13	177.40	139.59	105
110	0.00543	0.001002	136.19	137.19	-7.64	177.40	140.12	110
115	0.00559	0.001002	119.19	120.19	-7.20	177.40	140.63	115
120	0.00575	0.001002	104.19	105.19	-6.80	177.40	141.12	120
125	0.00591	0.001002	90.19	91.19	-6.43	177.40	141.59	125
130	0.00607	0.001002	78.19	79.19	-6.09	177.40	142.04	130
135	0.00623	0.001002	68.19	69.19	-5.78	177.40	142.47	135
140	0.00639	0.001002	59.19	60.19	-5.49	177.40	142.88	140
145	0.00655	0.001002	51.19	52.19	-5.22	177.40	143.27	145
150	0.00671	0.001002	44.19	45.19	-4.97	177.40	143.64	150
155	0.00687	0.001002	38.19	39.19	-4.74	177.40	143.99	155
160	0.00703	0.001002	33.19	34.19	-4.52	177.40	144.32	160
165	0.00719	0.001002	29.19	30.19	-4.31	177.40	144.63	165
170	0.00735	0.001002	26.19	27.19	-4.11	177.40	144.92	170
175	0.00751	0.001002	23.19	24.19	-3.92	177.40	145.19	175
180	0.00767	0.001002	20.19	21.19	-3.74	177.40	145.44	180
185	0.00783	0.001002	17.19	18.19	-3.57	177.40	145.67	185
190	0.00799	0.001002	14.19	15.19	-3.41	177.40	145.88	190
195	0.00815	0.001002	11.19	12.19	-3.26	177.40	146.07	195
200	0.00831	0.001002	8.19	9.19	-3.12	177.40	146.24	200
205	0.00847	0.001002	5.19	6.19	-2.99	177.40	146.39	205
210	0.00863	0.001002	2.19	3.19	-2.87	177.40	146.52	210
215	0.00879	0.001002	0.19	1.19	-2.76	177.40	146.63	215
220	0.00895	0.001002	0.01	0.01	-2.66	177.40	146.72	220
225	0.00911	0.001002	0.00	0.00	-2.57	177.40	146.79	225
230	0.00927	0.001002	0.00	0.00	-2.49	177.40	146.84	230
235	0.00943	0.001002	0.00	0.00	-2.42	177.40	146.88	235
240	0.00959	0.001002	0.00	0.00	-2.35	177.40	146.91	240
245	0.00975	0.001002	0.00	0.00	-2.29	177.40	146.93	245
250	0.00991	0.001002	0.00	0.00	-2.23	177.40	146.95	250
255	0.01007	0.001002	0.00	0.00	-2.18	177.40	146.96	255
260	0.01023	0.001002	0.00	0.00	-2.13	177.40	146.97	260
265	0.01039	0.001002	0.00	0.00	-2.08	177.40	146.97	265
270	0.01055	0.001002	0.00	0.00	-2.03	177.40	146.97	270
275	0.01071	0.001002	0.00	0.00	-1.98	177.40	146.96	275
280	0.01087	0.001002	0.00	0.00	-1.93	177.40	146.95	280
285	0.01103	0.001002	0.00	0.00	-1.88	177.40	146.93	285
290	0.01119	0.001002	0.00	0.00	-1.83	177.40	146.91	290
295	0.01135	0.001002	0.00	0.00	-1.78	177.40	146.88	295
300	0.01151	0.001002	0.00	0.00	-1.73	177.40	146.84	300
305	0.01167	0.001002	0.00	0.00	-1.68	177.40	146.79	305
310	0.01183	0.001002	0.00	0.00	-1.63	177.40	146.74	310
315	0.01199	0.001002	0.00	0.00	-1.58	177.40	146.68	315
320	0.01215	0.001002	0.00	0.00	-1.53	177.40	146.62	320
325	0.01231	0.001002	0.00	0.00	-1.48	177.40	146.55	325
330	0.01247	0.001002	0.00	0.00	-1.43	177.40	146.48	330
335	0.01263	0.001002	0.00	0.00	-1.38	177.40	146.40	335
340	0.01279	0.001002	0.00	0.00	-1.33	177.40	146.32	340
345	0.01295	0.001002	0.00	0.00	-1.28	177.40	146.23	345
350	0.01311	0.001002	0.00	0.00	-1.23	177.40	146.14	350
355	0.01327	0.001002	0.00	0.00	-1.18	177.40	146.04	355
360	0.01343	0.001002	0.00	0.00	-1.13	177.40	145.94	360
365	0.01359	0.001002	0.00	0.00	-1.08	177.40	145.83	365
370	0.01375	0.001002	0.00	0.00	-1.03	177.40	145.72	370
375	0.01391	0.001002	0.00	0.00	-0.98	177.40	145.60	375
380	0.01407	0.001002	0.00	0.00	-0.93	177.40	145.48	380
385	0.01423	0.001002	0.00	0.00	-0.88	177.40	145.35	385
390	0.01439	0.001002	0.00	0.00	-0.83	177.40	145.22	390
395	0.01455	0.001002	0.00	0.00	-0.78	177.40	145.08	395
400	0.01471	0.001002	0.00	0.00	-0.73	177.40	144.94	400
405	0.01487	0.001002	0.00	0.00	-0.68	177.40	144.79	405
410	0.01503	0.001002	0.00	0.00	-0.63	177.40	144.64	410
415	0.01519	0.001002	0.00	0.00	-0.58	177.40	144.48	415
420	0.01535	0.001002	0.00	0.00	-0.53	177.40	144.32	420
425	0.01551	0.001002	0.00	0.00	-0.48	177.40	144.15	425
430	0.01567	0.001002	0.00	0.00	-0.43	177.40	143.98	430
435	0.01583	0.001002	0.00	0.00	-0.38	177.40	143.80	435
440	0.01599	0.001002	0.00	0.00	-0.33	177.40	143.62	440
445	0.01615	0.001002	0.00	0.00	-0.28	177.40	143.43	445
450	0.01631	0.001002	0.00	0.00	-0.23	177.40	143.24	450
455	0.01647	0.001002	0.00	0.00	-0.18	177.40	143.04	455
460	0.01663	0.001002	0.00	0.00	-0.13	177.40	142.84	460
465	0.01679	0.001002	0.00	0.00	-0.08	177.40	142.63	465
470	0.01695	0.001002	0.00	0.00	-0.03	177.40	142.42	470
475	0.01711	0.001002	0.00	0.00	0.02	177.40	142.20	475
480	0.01727	0.001002	0.00	0.00	0.07	177.40	141.98	480
485	0.01743	0.001002	0.00	0.00	0.12	177.40	141.75	485
490	0.01759	0.001002	0.00	0.00	0.17	177.40	141.52	490
495	0.01775	0.001002	0.00	0.00	0.22	177.40	141.28	495
500	0.01791	0.001002	0.00	0.00	0.27	177.40	141.04	500

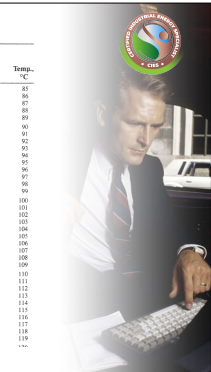


Temp. t, °C	Absolute Pressure, P, MPa	Specific Volume, m ³ /kg			Enthalpy, kJ/kg			Temp., t, °C
		Sat. Liquid v _f , /g	Evap. v _{fg} , /g	Sat. Vapor v _g , /g	Sat. Liquid h _f , /g	Evap. h _{fg} , /g	Sat. Vapor h _g , /g	
-40	0.00101	0.001002	9001.00	9002.00	-40.00	176.20	136.20	-40
-30	0.00124	0.001002	7081.00	7082.00	-44.76	176.46	131.72	-30
-20	0.00147	0.001002	5021.17	5022.17	-48.93	176.67	127.74	-20
-10	0.00169	0.001002	3489.19	3490.19	-52.66	176.84	125.18	-10
0	0.00191	0.001002	2406.97	2407.97	-56.06	176.97	123.91	0
5	0.00207	0.001002	1944.01	1945.01	-48.39	177.12	124.73	5
10	0.00223	0.001002	1606.19	1607.19	-43.57	177.22	125.65	10
15	0.00239	0.001002	1346.19	1347.19	-39.29	177.29	126.59	15
20	0.00255	0.001002	1136.19	1137.19	-35.44	177.34	127.50	20
25	0.00271	0.001002	994.19	995.19	-32.01	177.37	128.38	25
30	0.00287	0.001002	874.19	875.19	-28.93	177.39	129.24	30
35	0.00303	0.001002	774.19	775.19	-26.19	177.40	130.07	35
40	0.00319	0.001002	689.19	690.19	-23.74	177.40	130.88	40
45	0.00335	0.001002	616.19	617.19	-21.56	177.40	131.67	45
50	0.00351	0.001002	552.19	553.19	-19.61	177.40	132.44	50
55	0.00367	0.001002	495.19	496.19	-17.86	177.40	133.21	55
60	0.00383	0.001002	444.19	445.19	-16.31	177.40	133.97	60
65	0.00399	0.001002	398.19	399.19	-14.92	177.40	134.72	65
70	0.00415	0.001002	356.19	357.19	-13.66	177.40	135.46	70
75	0.00431	0.001002	318.19	319.19	-12.52	177.40	136.18	75
80	0.00447	0.001002	284.19	285.19	-11.48	177.40	136.89	80
85	0.00463	0.001002	253.19	254.19	-10.54	177.40	137.58	85
90	0.00479	0.001002	225.19	226.19	-9.69	177.40	138.26	90
95	0.00495	0.001002	199.19	200.19	-8.92	177.40	138.92	95
100	0.00511	0.001002	176.19	177.19	-8.23	177.40	139.57	100
105	0.00527	0.001002	155.19	156.19	-7.61	177.40	140.20	105
110	0.00543	0.001002	136.19	137.19	-7.04	177.40	140.82	110
115	0.00559	0.001002	119.19	120.19	-6.52	177.40	141.42	115
120	0.00575	0.001002	104.19	105.19	-6.04	177.40	142.01	120
125	0.00591	0.001002	90.19	91.19	-5.60	177.40	142.58	125
130	0.00607	0.001002	78.19	79.19	-5.19	177.40	143.14	130
135	0.00623	0.001002	68.19	69.19	-4.81	177.40	143.68	135
140	0.00639	0.001002	59.19	60.19	-4.45	177.40	144.21	140
145	0.00655	0.001002	51.19	52.19	-4.12	177.40	144.72	145
150	0.00671	0.001002	44.19	45.19	-3.81	177.40	145.22	150
155	0.00687	0.001002	38.19	39.19	-3.52	177.40	145.71	155
160	0.00703	0.001002	33.19	34.19	-3.25	177.40	146.18	160
165	0.00719	0.001002	29.19	30.19	-3.00	177.40	146.64	165
170	0.00735	0.001002	26.19	27.19	-2.77	177.40	147.08	170
175	0.00751	0.001002	23.19	24.19	-2.55	177.40	147.51	175
180	0.00767	0.001002	20.19	21.19	-2.35	177.40	147.93	180
185	0.00783	0.001002	17.19	18.19	-2.16	177.40	148.34	185
190	0.00799	0.001002	14.19	15.19	-1.99	177.40	148.74	190
195	0.00815	0.001002	11.19	12.19	-1.83	177.40	149.13	195
200	0.00831	0.001002	8.19	9.19	-1.69	177.40	149.51	200
205	0.00847	0.001002	5.19	6.19	-1.56	177.40	149.88	205
210	0.00863	0.001002	2.19	3.19	-1.44	177.40	150.24	210
215	0.00879	0.001002	0.19	1.19	-1.33	177.40	150.59	215
220	0.00895	0.001002	0.00	0.00	-1.23	177.40	150.93	220
225	0.00911	0.001002	0.00	0.00	-1.14	177.40	151.26	225
230	0.00927	0.001002	0.00	0.00	-1.06	177.40	151.58	230
235	0.00943	0.001002	0.00	0.00	-0.98	177.40	151.89	235
240	0.00959	0.001002	0.00	0.00	-0.91	177.40	152.19	240
245	0.00975	0.001002	0.00	0.00	-0.84	177.40	152.48	245
250	0.00991	0.001002	0.00	0.00	-0.78	177.40	152.76	250
255	0.01007	0.001002	0.00	0.00	-0.72	177.40	153.03	255
260	0.01023	0.001002	0.00	0.00	-0.67	177.40	153.29	260
265	0.01039	0.001002	0.00	0.00	-0.62	177.40	153.54	265
270	0.01055	0.001002	0.00	0.00	-0.57	177.40	153.78	270
275	0.01071	0.001002	0.00	0.00	-0.52	177.40	154.01	275
280	0.01087	0.001002	0.00	0.00	-0.48	177.40	154.23	280
285	0.01103	0.001002	0.00	0.00	-0.43	177.40	154.44	285
290	0.01119	0.001002	0.00	0.00	-0.39	177.40	154.64	290
295	0.01135	0.001002	0.00	0.00	-0.35	177.40	154.83	295
300	0.01151	0.001002	0.00	0.00	-0.31	177.40	155.01	300
305	0.01167	0.001002	0.00	0.00	-0.27	177.40	155.18	305
310	0.01183	0.001002	0.00	0.00	-0.23	177.40	155.34	310
315	0.01199	0.001002	0.00	0.00	-0.19	177.40	155.49	315
320	0.01215	0.001002	0.00	0.00	-0.15	177.40	155.63	320
325	0.01231	0.001002	0.00	0.00	-0.11	177.40	155.76	325
330	0.01247	0.001002	0.00	0.00	-0.07	177.40	155.88	330
335	0.01263	0.001002	0.00	0.00	-0.03	177.40	155.99	335
340	0.01279	0.001002	0.00	0.00	0.01	177.40	156.09	340
345	0.01295	0.001002	0.00	0.00	0.05	177.40	156.18	345
350	0.01311	0.001002	0.00	0.00	0.09	177.40	156.26	350
355	0.01327	0.001002	0.00	0.00	0.13	177.40	156.33	355
360	0.01343	0.001002	0.00	0.00	0.17	177.40	156.39	360
365	0.01359	0.001002	0.00	0.00	0.21	177.40	156.44	365
370	0.01375	0.001002	0.00	0.00	0.25	177.40	156.48	370
375	0.01391	0.001002	0.00	0.00	0.29	177.40	156.51	375
380	0.01407	0.001002	0.00	0.00	0.33	177.40	156.54	380
385	0.01423	0.001002	0.00	0.00	0.37	177.40	156.56	385
390	0.01439	0.001002	0.00	0.00	0.41	177.40	156.58	390
395	0.01455	0.001002	0.00	0.00	0.45	177.40	156.59	395
400	0.01471	0.001002	0.00	0.00	0.49	177.40	156.60	400
405	0.01487	0.001002	0.00	0.00	0.53	177.40	156.60	405
410	0.01503	0.001002	0.00	0.00	0.57	177.40	156.60	410
415	0.01519	0.001002	0.00	0.00	0.61	177.40	156.59	415
420	0.01535	0.001002	0.00	0.00	0.65	177.40	156.58	420
425	0.01551	0.001002	0.00	0.00	0.69	177.40	156.56	425
430	0.01567	0.001002	0.00	0.00	0.73	177.40	156.54	430
435	0.01583	0.001002	0.00	0.00	0.77	177.40	156.51	435
440	0.01599	0.001002	0.00	0.00	0.81	177.40	156.48	440
445	0.01615	0.001002	0.00	0.00	0.85	177.40	156.44	445
450	0.01631	0.001002	0.00	0.00	0.89	177.40	156.39	450
455	0.01647	0.001002	0.00	0.00	0.93	177.40	156.33	455
460	0.01663	0.001002	0.00	0.00	0.97	177.40	156.26	460
465	0.01679	0.001002	0.00	0.00	1.01	177.40	156.18	465
470	0.01695	0.001002	0.00	0.00	1.05	177.40	156.09	470
475	0.01711	0.001002	0.00	0.00	1.09	177.40	156.00	475
480	0.01727	0.001002	0.00	0.00	1.13	177.40	155.89	480
485	0.01743	0.001002	0.00	0.00	1.17	177.40	155.76	485
490	0.01759	0.001002	0.00	0.00	1.21	177.40	155.63	490
495	0.01775	0.001002	0.00	0.00	1.25	177.40	155.48	495
500	0.01791	0.001002	0.00	0.00	1.29	177.40	155.32	500
505	0.01807	0.001002	0.00	0.00	1.33	177.40	155.15	505
510	0.01823	0.001002	0.00	0.00	1.37	177.40	154.97	510
515	0.01839	0.001002	0.00	0.00	1.41	177.40	154.78	515
520	0.01855	0.001002	0.00	0.00	1.45	177.40	154.58	520
525	0.01871	0.001002	0.00	0.00	1.49	177.40	154.37	525
530	0.01887	0.001002	0.00	0.00	1.53	177.40	154.15	530
535	0.01903	0.001002	0.00	0.00	1.57	177.40	153.92	535
540	0.01919	0.001002	0.00	0.00	1.61	177.40	153.68	540
545	0.01935	0.001002	0.00	0.00	1.65	177.40	153.43	545
550	0.01951	0.001002	0.00	0.00	1.69	177.40	153.17	550
555	0.01967	0.001002	0.00	0.00	1.73	177.40	152.90	555
560	0.01983	0.001002	0.00	0.00	1.77	177.40	152.62	560
565	0.01999	0.001002	0.00	0.00	1.81	177.40	152.33	565
570	0.02015	0.001002	0.00	0.00	1.85	177.40	152.03	570
575	0.02031	0.001002	0.00	0.00	1.89	177.40	151.72	575
580	0.02047	0.001002	0.00	0.00	1.93	177.40	151.40	580
585	0.02063	0.001002	0.00	0.00	1.97	177.40	151.07	585
590	0.02079	0.001002	0.00	0.00	2.01	177.40	150.73	590
595	0.02095	0.001002	0.00	0.00	2.05	177.40	150.38	595
600	0.02111	0.001002	0.00	0.00	2.09	177.40	150.02	600
605	0.02127	0.001002	0.00	0.00	2.13	177.40	149.65	605
610	0.02143	0.001002	0.00	0.00	2.17	177.40	149.27	610
615	0.02159	0.001002	0.00	0.00	2.21	177.40	148.88	615

Temp. t, °C	Pressure, P, kPa	Sat. Liquid v _f , m ³ /kg	Exp. v _g /v _f	Sat. Liquid u _f , kJ/kg	Exp. h _g /h _f	Sat. Vapor u _g , kJ/kg	Sat. Liquid v _f , m ³ /kg	Exp. v _g /v _f	Sat. Vapor u _g , kJ/kg	Temp. t, °C
46	10.0976	0.00010	14.337	14.538	192.40	2291.39	0.00010	14.337	14.538	46
47	10.4266	0.00011	13.835	13.859	196.78	2309.18	0.00011	13.835	13.859	47
48	11.1771	0.00011	13.234	13.217	200.97	2326.77	0.00011	13.234	13.217	48
49	11.7500	0.00012	12.606	12.607	205.15	2344.36	0.00012	12.606	12.607	49
50	12.2409	0.00012	12.029	12.029	209.33	2361.94	0.00012	12.029	2361.94	50
51	12.7599	0.00013	11.482	11.483	213.51	2379.53	0.00013	11.482	2379.53	51
52	13.2869	0.00013	10.964	10.965	217.69	2397.12	0.00013	10.964	2397.12	52
53	13.8310	0.00014	10.474	10.474	221.88	2414.71	0.00014	10.474	2414.71	53
54	14.3924	0.00014	10.008	10.008	226.06	2432.30	0.00014	10.008	2432.30	54
55	14.9703	0.00015	9.563	9.563	230.25	2450.00	0.00015	9.563	2450.00	55
56	15.5648	0.00015	9.147	9.148	234.43	2467.79	0.00015	9.147	2467.79	56
57	16.1761	0.00016	8.758	8.759	238.62	2485.58	0.00016	8.758	2485.58	57
58	16.8044	0.00016	8.394	8.395	242.81	2503.37	0.00016	8.394	2503.37	58
59	17.4507	0.00017	8.046	8.047	247.00	2521.16	0.00017	8.046	2521.16	59
60	18.1150	0.00017	7.717	7.717	251.19	2538.95	0.00017	7.717	2538.95	60
61	18.8000	0.00018	7.406	7.406	255.38	2556.74	0.00018	7.406	2556.74	61
62	19.5075	0.00018	7.113	7.113	259.57	2574.53	0.00018	7.113	2574.53	62
63	20.2384	0.00019	6.837	6.837	263.76	2592.32	0.00019	6.837	2592.32	63
64	21.0036	0.00019	6.578	6.578	267.95	2610.11	0.00019	6.578	2610.11	64
65	21.8040	0.00020	6.335	6.335	272.14	2627.90	0.00020	6.335	2627.90	65
66	22.6404	0.00020	6.107	6.107	276.33	2645.69	0.00020	6.107	2645.69	66
67	23.5136	0.00021	5.894	5.894	280.52	2663.48	0.00021	5.894	2663.48	67
68	24.4244	0.00021	5.695	5.695	284.71	2681.27	0.00021	5.695	2681.27	68
69	25.3736	0.00022	5.510	5.510	288.90	2699.06	0.00022	5.510	2699.06	69
70	26.3620	0.00022	5.338	5.338	293.09	2716.85	0.00022	5.338	2716.85	70
71	27.3904	0.00023	5.179	5.179	297.28	2734.64	0.00023	5.179	2734.64	71
72	28.4596	0.00023	5.032	5.032	301.47	2752.43	0.00023	5.032	2752.43	72
73	29.5704	0.00024	4.896	4.896	305.66	2770.22	0.00024	4.896	2770.22	73
74	30.7236	0.00024	4.771	4.771	309.85	2788.01	0.00024	4.771	2788.01	74
75	31.9190	0.00025	4.656	4.656	314.04	2805.80	0.00025	4.656	2805.80	75
76	33.1564	0.00025	4.551	4.551	318.23	2823.59	0.00025	4.551	2823.59	76
77	34.4356	0.00026	4.456	4.456	322.42	2841.38	0.00026	4.456	2841.38	77
78	35.7564	0.00026	4.371	4.371	326.61	2859.17	0.00026	4.371	2859.17	78
79	37.1186	0.00027	4.296	4.296	330.80	2876.96	0.00027	4.296	2876.96	79
80	38.5220	0.00027	4.231	4.231	335.00	2894.75	0.00027	4.231	2894.75	80
81	39.9664	0.00028	4.176	4.176	339.19	2912.54	0.00028	4.176	2912.54	81
82	41.4516	0.00028	4.131	4.131	343.38	2930.33	0.00028	4.131	2930.33	82
83	42.9774	0.00029	4.096	4.096	347.57	2948.12	0.00029	4.096	2948.12	83
84	44.5436	0.00029	4.071	4.071	351.76	2965.91	0.00029	4.071	2965.91	84



Table 2-15 Thermodynamic Properties of Water (Continued)													
		Specific Volume, m ³ /kg				Enthalpy, kJ/kg				Entropy, kJ/kg·K			
Temp., °C	Pressure, kPa	Sat. Liquid	Exp. Vapor	Sat. Liquid	Exp. Vapor	Sat. Liquid	Exp. Vapor	Sat. Liquid	Exp. Vapor	Sat. Liquid	Exp. Vapor	Sat. Liquid	Exp. Vapor
85	46.1592	0.00030	4.046	355.95	2983.70	0.00030	4.046	355.95	2983.70	1.1339	6.9854	1.1339	6.9854
86	47.7136	0.00030	4.021	360.14	3001.49	0.00030	4.021	360.14	3001.49	1.1463	6.9384	1.1463	6.9384
87	49.3060	0.00031	4.006	364.33	3019.28	0.00031	4.006	364.33	3019.28	1.1588	6.8914	1.1588	6.8914
88	50.9364	0.00031	4.001	368.52	3037.07	0.00031	4.001	368.52	3037.07	1.1713	6.8444	1.1713	6.8444
89	52.6048	0.00032	3.996	372.71	3054.86	0.00032	3.996	372.71	3054.86	1.1838	6.7974	1.1838	6.7974
90	54.3112	0.00032	3.991	376.90	3072.65	0.00032	3.991	376.90	3072.65	1.1963	6.7504	1.1963	6.7504
91	56.0556	0.00033	3.986	381.09	3090.44	0.00033	3.986	381.09	3090.44	1.2088	6.7034	1.2088	6.7034
92	57.8380	0.00033	3.981	385.28	3108.23	0.00033	3.981	385.28	3108.23	1.2213	6.6564	1.2213	6.6564
93	59.6584	0.00034	3.976	389.47	3126.02	0.00034	3.976	389.47	3126.02	1.2338	6.6094	1.2338	6.6094
94	61.5168	0.00034	3.971	393.66	3143.81	0.00034	3.971	393.66	3143.81	1.2463	6.5624	1.2463	6.5624
95	63.4132	0.00035	3.966	397.85	3161.60	0.00035	3.966	397.85	3161.60	1.2588	6.5154	1.2588	6.5154
96	65.3476	0.00035	3.961	402.04	3179.39	0.00035	3.961	402.04	3179.39	1.2713	6.4684	1.2713	6.4684
97	67.3190	0.00036	3.956	406.23	3197.18	0.00036	3.956	406.23	3197.18	1.2838	6.4214	1.2838	6.4214
98	69.3274	0.00036	3.951	410.42	3214.97	0.00036	3.951	410.42	3214.97	1.2963	6.3744	1.2963	6.3744
99	71.3728	0.00037	3.946	414.61	3232.76	0.00037	3.946	414.61	3232.76	1.3088	6.3274	1.3088	6.3274
100	73.4552	0.00037	3.941	418.80	3250.55	0.00037	3.941	418.80	3250.55	1.3213	6.2804	1.3213	6.2804
101	75.5746	0.00038	3.936	422.99	3268.34	0.00038	3.936	422.99	3268.34	1.3338	6.2334	1.3338	6.2334
102	77.7300	0.00038	3.931	427.18	3286.13	0.00038	3.931	427.18	3286.13	1.3463	6.1864	1.3463	6.1864
103	79.9214	0.00039	3.926	431.37	3303.92	0.00039	3.926	431.37	3303.92	1.3588	6.1394	1.3588	6.1394
104	82.1488	0.00039	3.921	435.56	3321.71	0.00039	3.921	435.56	3321.71	1.3713	6.0924	1.3713	6.0924
105	84.4122	0.00039	3.916	439.75	3339.50	0.00039	3.916	439.75	3339.50	1.3838	6.0454	1.3838	6.0454
106	86.7116	0.00040	3.911	443.94	3357.29	0.00040	3.911	443.94	3357.29	1.3963	5.9984	1.3963	5.9984
107	89.0470	0.00040	3.906	448.13	3375.08	0.00040	3.906	448.13	3375.08	1.4088	5.9514	1.4088	5.9514
108	91.4184	0.00041	3.901	452.32	3392.87	0.00041	3.901	452.32	3392.87	1.4213	5.9044	1.4213	5.9044
109	93.8258	0.00041	3.896	456.51	3410.66	0.00041	3.896	456.51	3410.66	1.4338	5.8574	1.4338	5.8574
110	96.2692	0.00042	3.891	460.70	3428.45	0.00042	3.891	460.70	3428.45	1.4463	5.8104	1.4463	5.8104
111	98.7486	0.00042	3.886	464.89	3446.24	0.00042	3.886	464.89	3446.24	1.4588	5.7634	1.4588	5.7634
112	101.2640	0.00043	3.881	469.08	3464.03	0.00043	3.881	469.08	3464.03	1.4713	5.7164	1.4713	5.7164
113	103.8154	0.00043	3.876	473.27	3481.82	0.00043	3.876	473.27	3481.82	1.4838	5.6694	1.4838	5.6694
114	106.4028	0.00044	3.871	477.46	3500.00	0.00044	3.871	477.46	3500.00	1.4963	5.6224	1.4963	5.6224
115	109.0262	0.00044	3.866	481.65	3518.19	0.00044	3.866	481.65	3518.19	1.5088	5.5754	1.5088	5.5754
116	111.6856	0.00045	3.861	485.84	3536.38	0.00045	3.861	485.84	3536.38	1.5213	5.5284	1.5213	5.5284
117	114.3800	0.00045	3.856	490.03	3554.57	0.00045	3.856	490.03	3554.57	1.5338	5.4814	1.5338	5.4814
118	117.1104	0.00046	3.851	494.22	3572.76	0.00046	3.851	494.22	3572.76	1.5463	5.4344	1.5463	5.4344
119	119.8768	0.00046	3.846	498.41	3590.95	0.00046	3.846	498.41	3590.95	1.5588	5.3874	1.5588	5.3874



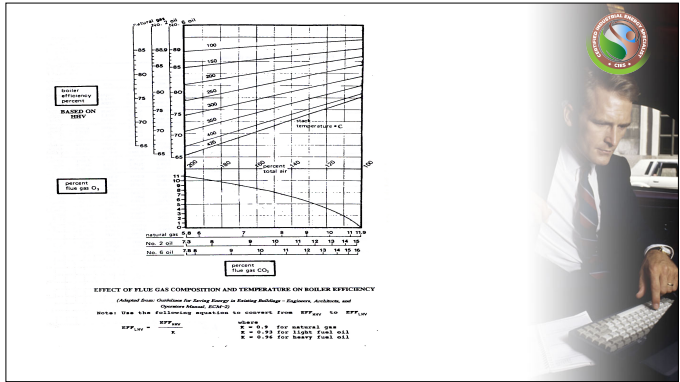
117	189.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
118	190.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
119	191.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
120	192.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
121	193.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
122	194.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
123	195.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
124	196.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
125	197.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
126	198.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
127	199.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
128	200.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
129	201.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
130	202.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
131	203.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
132	204.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
133	205.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
134	206.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
135	207.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
136	208.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
137	209.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
138	210.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
139	211.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
140	212.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
141	213.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
142	214.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
143	215.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
144	216.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
145	217.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
146	218.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
147	219.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
148	220.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
149	221.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
150	222.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
151	223.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
152	224.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
153	225.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
154	226.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
155	227.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
156	228.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
157	229.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
158	230.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
159	231.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
160	232.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
161	233.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
162	234.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
163	235.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
164	236.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
165	237.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
166	238.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
167	239.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
168	240.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
169	241.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
170	242.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
171	243.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
172	244.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
173	245.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
174	246.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
175	247.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
176	248.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
177	249.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
178	250.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
179	251.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
180	252.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
181	253.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
182	254.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				
183	255.00	0.00056	1.0488	1.0379	482.59	2217.23	2696.66	44.94	5.0686	7.1822				

Pressure, bar	Pressure, pPa	Temperature, °C	Specific volume, m ³ /kg		Specific enthalpy, kJ/kg			Specific entropy, kJ/kgK	
			v _g	v _f	h _g	h _f	h _{fg}	s _g	s _f
0.010	0.1420	6.98	0.0010001	129.20	29.30	2484.9	2514.2	0.1054	8.8714
0.015	0.2176	13.04	0.0010007	87.18	54.71	2470.6	2525.3	0.1198	8.8312
0.020	0.2903	17.51	0.0010014	67.00	73.48	2460.0	2533.5	0.1268	8.8209
0.025	0.3628	21.06	0.0010021	54.24	88.49	2451.6	2540.0	0.1300	8.1340
0.030	0.4351	24.10	0.0010028	45.66	101.05	2444.5	2545.5	0.1310	8.1328
0.040	0.5802	28.98	0.0010041	34.81	121.46	2432.9	2554.4	0.1349	8.1318
0.050	0.7525	32.90	0.0010052	28.19	137.82	2423.7	2561.5	0.1362	8.1313
0.060	0.9102	36.16	0.0010064	23.74	151.30	2415.0	2566.9	0.1370	8.1309
0.070	1.0519	39.03	0.0010075	20.33	163.43	2409	2572.4	0.1376	8.1304
0.080	1.1803	41.54	0.0010085	18.10	173.9	2402.6	2576.5	0.1381	8.1304
0.090	1.3023	43.79	0.0010094	16.20	183.3	2396.7	2580.0	0.1385	8.1303
0.10	1.4194	45.84	0.0010102	14.68	191.9	2392.3	2584.2	0.1388	8.1304
0.11	1.4954	47.72	0.0010111	13.40	199.7	2388.3	2588.0	0.1392	8.1304
0.12	1.5625	49.43	0.0010120	12.36	207.1	2384.5	2591.6	0.1395	8.1304
0.14	1.7025	52.80	0.0010133	9.69	220.3	2373.8	2596.1	0.1401	8.1304
0.16	1.8206	55.34	0.0010151	8.433	231.9	2365.1	2601.0	0.1408	8.1304
0.18	1.9197	57.82	0.0010169	7.465	241.4	2358.5	2605.1	0.1414	8.1304
0.20	2.0008	60.09	0.0010187	6.669	251.9	2353.4	2609.3	0.1420	8.1304
0.25	2.3259	66.99	0.0010220	5.204	272.8	2343.1	2617.7	0.1434	8.1304
0.30	2.6991	73.88	0.0010252	4.136	289.9	2334.9	2624.8	0.1445	8.1304
0.40	3.9133	85.93	0.0010319	3.193	318.3	2318.0	2636.3	0.1470	8.1304
0.50	5.0510	99.64	0.0010390	2.460	341.3	2304.1	2644.4	0.1490	8.1304
0.60	6.1023	105.95	0.0010453	2.023	360.6	2292.4	2653.0	0.1501	8.1304
0.80	11.030	113.32	0.0010588	1.587	392.3	2273.0	2665.3	0.1534	8.1304
1.0	14.528	119.64	0.0010643	1.464	418.0	2257.0	2675.0	0.1558	8.1304
1.013	14.696	120	0.0010643	1.473	419.3	2256.1	2675.6	0.1559	8.1304

0.01	11.4038	93.52	0.001028	2.087	392.3	2273.0	2665.3	0.1544	8.1304
1.0	14.5028	104.84	0.0010603	1.464	418.0	2257.0	2675.0	0.1558	8.1304
1.013	14.6966	105	0.0010604	1.473	419.3	2256.1	2675.6	0.1559	8.1304
1.2	17.4008	119.43	0.0010697	1.438	438.7	2243.4	2681.1	0.1571	8.1304
1.4	19.3393	130.83	0.0010751	1.37	458.6	2231.0	2686.0	0.1581	8.1304
1.6	21.306	141.3	0.0010804	1.291	478.5	2219.3	2690.0	0.1591	8.1304
1.8	23.307	151.9	0.0010858	1.21	498.9	2208.2	2694.0	0.1601	8.1304
2.0	25.348	162.7	0.0010911	1.137	519.7	2197.6	2698.0	0.1611	8.1304
2.5	30.259	174.9	0.0011017	0.917	552.3	2181.3	2705.6	0.1631	8.1304
3.0	35.131	187.6	0.0011123	0.752	585.7	2165.9	2713.0	0.1651	8.1304
4.0	45.013	209.9	0.0011284	0.586	642.3	2138.8	2728.1	0.1681	8.1304
5.0	55.019	231.9	0.0011445	0.481	699.8	2114.2	2740.6	0.1701	8.1304
6.0	65.023	253.9	0.0011606	0.417	757.3	2091.3	2750.6	0.1721	8.1304
8.0	85.027	294.9	0.0011967	0.312	874.8	2060.6	2769.4	0.1761	8.1304
10	105.031	335.9	0.0012328	0.247	992.3	2032.0	2786.3	0.1791	8.1304
12	125.035	376.9	0.0012689	0.202	1109.8	2005.4	2800.2	0.1821	8.1304
14	145.039	417.9	0.0013050	0.167	1227.3	1980.9	2812.1	0.1851	8.1304
16	165.043	458.9	0.0013411	0.142	1344.8	1958.4	2822.2	0.1881	8.1304
18	185.047	499.9	0.0013772	0.127	1462.3	1937.9	2830.6	0.1911	8.1304
20	205.051	540.9	0.0014133	0.112	1579.8	1919.4	2837.3	0.1941	8.1304
25	260.055	640.9	0.0014844	0.087	1842.3	1870.9	2851.2	0.2001	8.1304
30	315.059	740.9	0.0015555	0.072	2104.8	1824.4	2863.6	0.2061	8.1304
35	370.063	840.9	0.0016266	0.067	2367.3	1780.9	2874.2	0.2121	8.1304
40	425.067	940.9	0.0016977	0.062	2629.8	1739.4	2883.2	0.2181	8.1304
45	480.071	1040.9	0.0017688	0.057	2892.3	1699.9	2890.2	0.2241	8.1304
50	535.075	1140.9	0.0018399	0.052	3154.8	1662.4	2895.2	0.2301	8.1304
60	640.079	1340.9	0.0019710	0.047	3717.3	1604.9	2902.4	0.2401	8.1304
70	745.083	1540.9	0.0021021	0.042	4279.8	1550.4	2907.6	0.2501	8.1304
80	850.087	1740.9	0.0022332	0.037	4842.3	1498.9	2910.6	0.2601	8.1304
90	955.091	1940.9	0.0023643	0.032	5404.8	1450.4	2911.6	0.2701	8.1304
100	1060.095	2140.9	0.0024954	0.027	5967.3	1404.9	2910.6	0.2801	8.1304
110	1165.100	2340.9	0.0026265	0.022	6529.8	1361.4	2907.6	0.2901	8.1304
120	1270.104	2540.9	0.0027576	0.017	7092.3	1320.9	2902.6	0.3001	8.1304
130	1375.108	2740.9	0.0028887	0.012	7654.8	1282.4	2895.6	0.3101	8.1304
140	1480.112	2940.9	0.0030198	0.007	8217.3	1245.9	2885.6	0.3201	8.1304
150	1585.116	3140.9	0.0031509	0.002	8779.8	1211.4	2872.6	0.3301	8.1304
160	1690.120	3340.9	0.0032820	0.001	9342.3	1178.9	2856.6	0.3401	8.1304
170	1795.124	3540.9	0.0034131	0.000	9904.8	1148.4	2837.6	0.3501	8.1304
180	1900.128	3740.9	0.0035442	0.000	10467.3	1119.9	2815.6	0.3601	8.1304
190	2005.132	3940.9	0.0036753	0.000	11029.8	1093.4	2790.6	0.3701	8.1304
200	2110.136	4140.9	0.0038064	0.000	11592.3	1068.9	2762.6	0.3801	8.1304
210	2215.140	4340.9	0.0039375	0.000	12154.8	1046.4	2731.6	0.3901	8.1304
220	2320.144	4540.9	0.0040686	0.000	12717.3	1025.9	2698.6	0.4001	8.1304
230	2425.148	4740.9	0.0041997	0.000	13279.8	1007.4	2663.6	0.4101	8.1304
240	2530.152	4940.9	0.0043308	0.000	13842.3	989.9	2626.6	0.4201	8.1304
250	2635.156	5140.9	0.0044619	0.000	14404.8	976.4	2587.6	0.4301	8.1304
260	2740.160	5340.9	0.0045930	0.000	14967.3	963.9	2546.6	0.4401	8.1304
270	2845.164	5540.9	0.0047241	0.000	15529.8	953.4	2503.6	0.4501	8.1304
280	2950.168	5740.9	0.0048552	0.000	16092.3	944.9	2458.6	0.4601	8.1304
290	3055.172	5940.9	0.0049863	0.000	16654.8	938.4	2411.6	0.4701	8.1304
300	3160.176	6140.9	0.0051174	0.000	17217.3	933.9	2362.6	0.4801	8.1304
310	3265.180	6340.9	0.0052485	0.000	17779.8	928.9	2311.6	0.4901	8.1304
320	3370.184	6540.9	0.0053796	0.000	18342.3	924.4	2258.6	0.5001	8.1304
330	3475.188	6740.9	0.0055107	0.000	18904.8	920.9	2203.6	0.5101	8.1304
340	3580.192	6940.9	0.0056418	0.000	19467.3	917.4	2146.6	0.5201	8.1304
350	3685.196	7140.9	0.0057729	0.000	20029.8	914.9	2087.6	0.5301	8.1304
360	3790.200	7340.9	0.0059040	0.000	20592.3	912.4	2026.6	0.5401	8.1304
370	3895.204	7540.9	0.0060351	0.000	21154.8	910.9	1963.6	0.5501	8.1304
380	4000.208	7740.9	0.0061662	0.000	21717.3	909.4	1898.6	0.5601	8.1304
390	4105.212	7940.9	0.0062973	0.000	22279.8	908.9	1831.6	0.5701	8.1304
400	4210.216	8140.9	0.0064284	0.000	22842.3	909.4	1762.6	0.5801	8.1304
410	4315.220	8340.9	0.0065595	0.000	23404.8	910.9	1691.6	0.5901	8.1304
420	4420.224	8540.9	0.0066906	0.000	23967.3	913.4	1618.6	0.6001	8.1304
430	4525.228	8740.9	0.0068217	0.000	24529.8	917.9	1543.6	0.6101	8.1304
440	4630.232	8940.9	0.0069528	0.000	25092.3	923.4	1466.6	0.6201	8.1304
450	4735.236	9140.9	0.0070839	0.000	25654.8	930.9	1387.6	0.6301	8.1304
460	4840.240	9340.9	0.0072150	0.000	26217.3	939.4	1306.6	0.6401	8.1304
470	4945.244	9540.9	0.0073461	0.000	26779.8	949.9	1223.6	0.6501	8.1304
480	5050.248	9740.9	0.0074772	0.000	27342.3	961.4	1138.6	0.6601	8.1304
490	5155.252	9940.9	0.0076083	0.000	27904.8	974.9	1051.6	0.6701	8.1304
500	5260.256	10140.9	0.0077394	0.000	28467.3	989.4	962.6	0.6801	8.1304
510	5365.260	10340.9	0.0078705	0.000	29029.8	1005.9	871.6	0.6901	8.1304
520	5470.264	10540.9	0.0080016	0.000	29592.3	1024.4	778.6	0.7001	8.1304
530	5575.268	10740.9	0.0081327	0.000	30154.8	1044.9	683.6	0.7101	8.1304
540	5680.272	10940.9	0.0082638	0.000	30717.3	1067.4	586.6	0.7201	8.1304
550	5785.276	11140.9	0.0083949	0.000	31279.8	1091.9	487.6	0.7301	8.1304
560	5890.280	11340.9	0.0085260	0.000	31842.3	1118.4	386.6	0.7401	8.1304
570	5995.284	11540.9	0.0086571	0.000	32404.8	1146.9	283.6	0.7501	8.1304
580	6100.288	11740.9	0.0087882	0.000	32967.3	1177.4	178.6	0.7601	8.1304
590	6205.292	11940.9	0.008919	0.000	33529.8	1210.9	83.6	0.7701	8.1304
600	6310.296	12140.9	0.0090501	0.000	34092.3	1246.4	-117.4	0.7801	8.1304
610	6415.300	12340.9	0.0091812	0.000	34654.8	1283.9	-218.4	0.7901	8.1304
620	6520.304	12540.9	0.0093123	0.000	35217.3	1323.4	-319.4	0.8001	8.1304
630	6625.308	12740.9	0.0094434	0.000	35779.8	1364.9	-420.4	0.8101	8.1304
640	6730.312	12940.9	0.0095745	0.000	36342.3	1408.4	-521.4	0.8201	8.1304
650	6835.316	13140.9	0.0097056	0.000	36904.8	1453.9	-622.4	0.8301	8.1304
660	6940.320	13340.9	0.0098367	0.000	37467.3	1501.4	-723.4	0.8401	8.1304
670	7045.324	13540.9	0.0099678	0.000	38029.8	1550.9	-824.4	0.8501	8.1304
680	7150.328	13740.9	0.0100989	0.000	38592.3	1602.4	-925.4	0.8601	8.1304
690	7255.332	13940.9	0.0102300	0.000	39154.8	1655.9	-1026.4	0.8701	8.1304
700	7360.336	14140.9	0.0103611	0.000	39717.3	1711.4	-1127.4	0.8801	8.1304
710	7465.340	14340.9	0.0104922	0.000	40279.8	1768.9	-1228.4	0.8901	8.1304
720	7570.344	14540.9	0.0106233	0.000	40842.3	1828.4	-1329.4	0.9001	8.1304
730	7675.348	14740.9	0.0107544	0.000	41404.8	1889.9	-1430.4	0.9101	8.1304
740	7780.352	14940.9	0.0108855	0.000	41967.3	1953.4	-1531.4	0.9201	8.1304
750	7885.356	15140.9	0.0110166	0.000	42529.8	2018.9	-1632.4	0.9301	8.1304
760	7990.360	15340.9	0.0111477	0.000	43092.3	2086.4	-1733.4	0.9401	8.1304
770	8095.364	15540.9	0.0112788	0.000	43654.8	2155.9	-1834.4	0.9501	8.1304
780	8200.368	15740.9	0.0114099	0.000	44217.3	2227.4	-1935.4	0.9601	8.1304
790	8305.372	15940.9	0.0115410	0.000	44779.8	2300.9	-2036.4	0.9701	8.1304
800	8410.376	16140.9	0.0116721	0.000	45342.3	2376.4	-2137.4	0.9801	8.1304
810	8515.380	16340.9	0.0118032	0.000	45904.8	2453.9	-2238.4	0.9901	8.1304
820	8620.384	16540.9	0.0119343	0.000	46467.3	2533.4	-2339.4	1.0001	8.1304
830	8725.388	16740.9	0.0120654	0.000	47029.8	2614.9	-2440.4	1.0101	8.1304
840	8830.392	16940.9	0.0121965	0.000	47592.3	2698.4	-2541.4	1.0201	8.1304
850	8935.396	17140.9	0.0123276	0.000	48154.8	2783.9	-2642.4	1.0301	8.1304
860	9040.400	17340.9	0.0124587	0.000	48717.3	2871.4	-2743.4	1	



10	y	0.2060	0.2327	0.2579	0.2866	0.3241	0.4031	0.4478	0.4923
(179.91)	A	2827.9	2942.6	3051.2	3163.9	3478.5	3697.9	3923.1	4164.7
	x	6.6940	6.9247	7.1229	7.4451	7.7622	8.0290	8.2731	8.4996
20	y	0.1114	0.1255	0.1392	0.1512	0.1757	0.1996	0.2232	0.2467
(212.42)	A	2902.5	3023.5	3147.6	3467.6	3690.1	3917.4	4150.3	
	x	6.5453	6.7664	7.1271	7.4317	7.7024	7.9487	8.1765	
30	y	0.0758	0.08114	0.0994	0.1162	0.1324	0.1484	0.1641	
(233.9)	A	2855.8	2991.5	3230.9	3456.5	3682.3	3911.7	4145.9	
	x	6.3872	6.5390	6.9132	7.2338	7.5085	7.7571	7.9862	
40	y	0.0588	0.0734	0.0864	0.09885	0.11095	0.12287		
(250.4)	A	2960.7	3213.6	3445.3	3674.4	3905.9	4141.5		
	x	6.3615	6.7890	7.0901	7.3688	7.6198	7.8302		
50	y	0.0453	0.0578	0.06857	0.07869	0.08849	0.0981		
(263.99)	A	2924.5	3195.7	3431.8	3666.5	3900.1	4137.1		
	x	6.2884	6.6459	6.9759	7.2289	7.5122	7.7440		
60	y	0.0362	0.0474	0.0567	0.0653	0.0735	0.0816		
(275.64)	A	2884.2	3177.2	3422.2	3658.4	3894.2	4132.7		
	x	6.0874	6.5408	6.8803	7.1677	7.4234	7.6566		
70	y	0.0295	0.0393	0.0481	0.0557	0.0628	0.0698		
(285.88)	A	2838.4	3158.1	3405.3	3650.3	3888.3	4128.2		
	x	5.9305	6.4478	6.7975	7.0894	7.3476	7.5822		




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