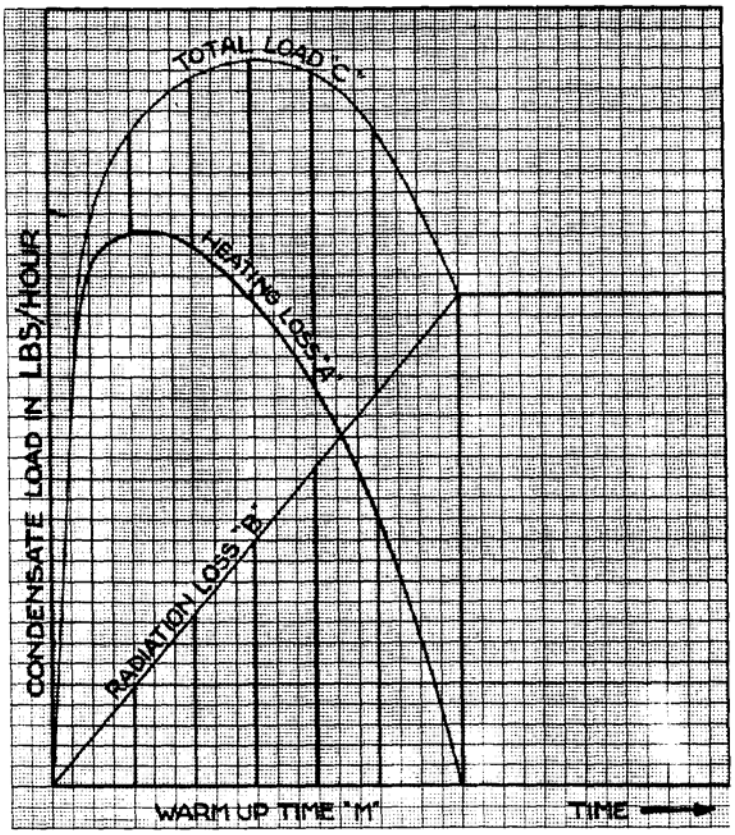
Calculating Condensate Loads

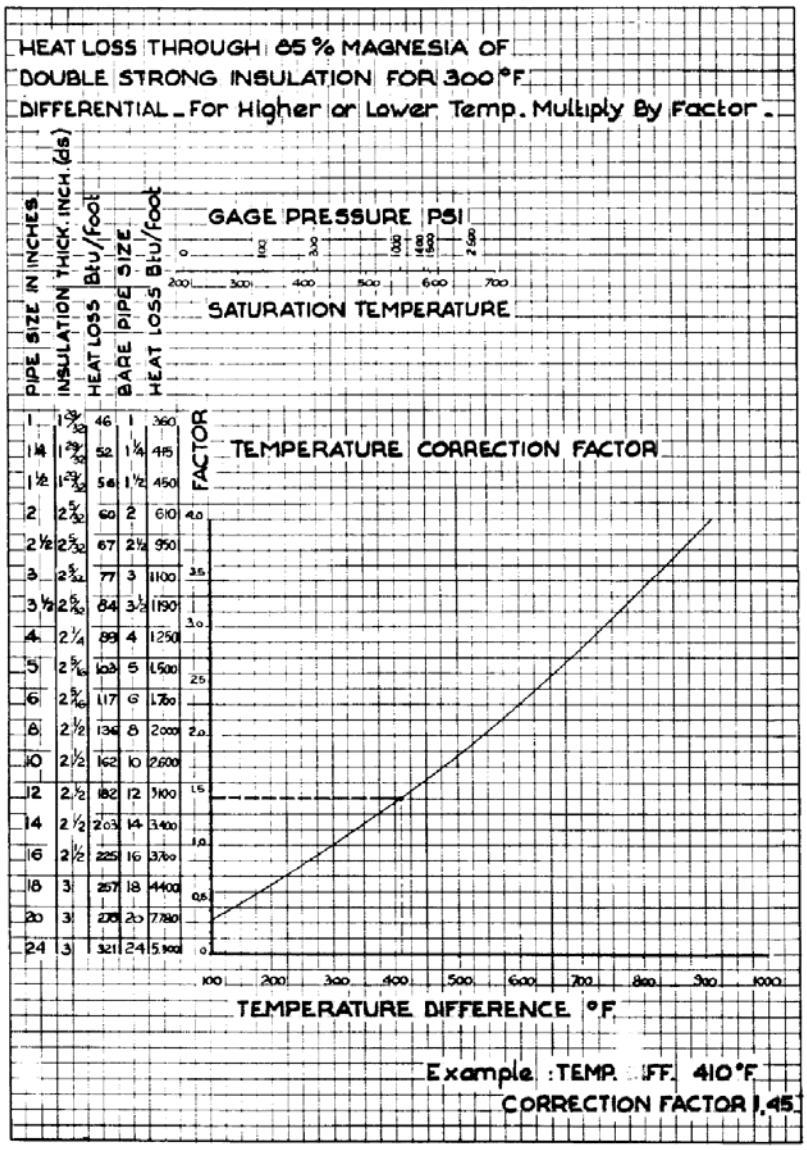


Warm Up Load (Heating Loss)

This is the amount of condensate which forms at starting up a power plant to raise the temperature of the metal of pipes, fittings, etc. to the operating temperature without including the normal radiation loss. As far as calculating the condensation load during the warming up period the required time is extremely important for sizing steam traps. Less warm up time increases the necessary capacity per trap. Allowing more time for warm up permits the use of smaller traps in smaller quantity.

$$Q = \frac{W \times (T-t) \times \text{Sp. Heat} \times 60}{L \times m}$$

Where Q = Quantity of Condensate (Lbs/hr)
W = Total weight of pipes in LBS
T = Saturation Steam Temp (°F)
t = initial temp of pipe (°F) usually surrounding air temp
m = minutes to heat up system
L = Latent heat of steam (BTU's/Hr)



Normal Condensate Load (Radiation Loss)

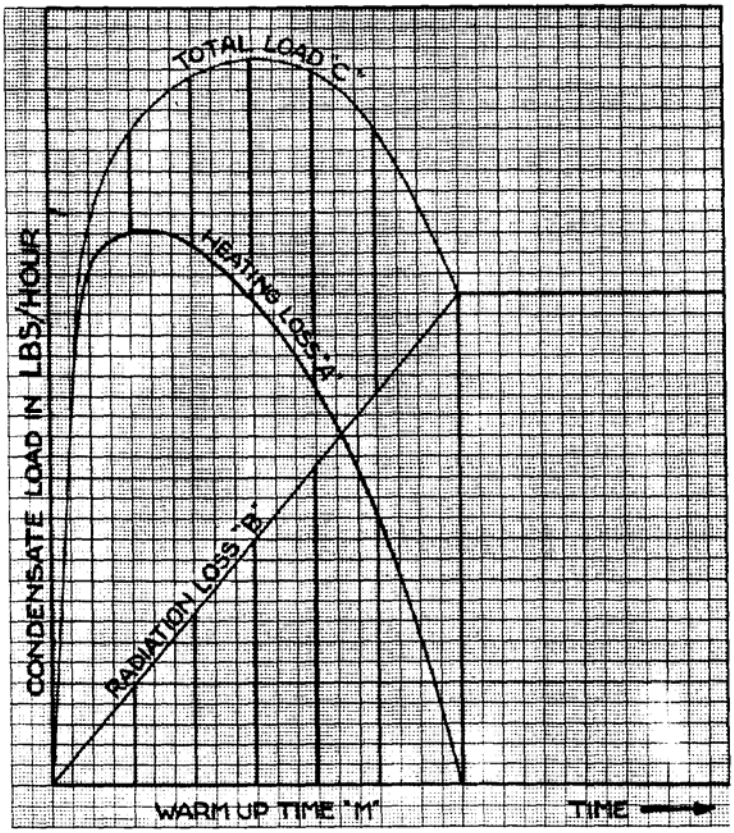
Once the system is heated up steam condenses due to normal radiation losses to the surrounding air. These losses depend of course on the size and length of the pipe, on the pressure of steam and its latent heat and mainly on the type and thickness of insulation. The equation from which a normal regulation load can be calculated is:

$$Q = \frac{F \times HL\,(T - t)}{L}$$

Where F = Length of Pipe (ft)

HL (T – t) = Heat loss/foot of pipe at the temperature differential between steam and air Above Table

L = Latent heat of steam (BTU's/Hr.)



Condensation Load for Sizing Steam Traps

The condensation load builds up from 0 to maximum at the point where the warming up load drops to 0. It is assumed, therefore, that the peak is achieved halfway through the warming up period. Therefore, for sizing of steam traps, we take the maximum amount of condensate during the warming up period plus half of the radiation load.

$Q_t = Q_W + .5Q_R$

Where Q_t = Total condensation load at peak (LBS/Hr)
Q_W = Condensation load during warm up (LBS/Hr)
Q_R = Condensation load due to normal radiation loss (LBS/Hr)

Condensate in LBS/Hr created in steam mains 1" to 24" and pressure of 600 to 2500 PSI based on the warm up period of 1 hour and 100 feet of pipe, and based on the above assumption is shown in tables.

For shorter or longer heating up time, multiply by 60/m where m is the warm up time in minutes.

Properties of Saturated Steam

Gauge Pressure PSIG	Temp °F	Sensible	Heat in BTU/lb Latent	Total	Specific Volume Cu. Ft./lb			Gauge Pressure PSIG	Temp °F	Sensible	Heat in BTU/lb Latent	Total	Specific Volume Cu. Ft./lb
25	134	102	1017	1119	142			150	366	339	857	1196	2.74
20	162	129	1001	1130	73.9			155	368	341	855	1196	2.68
15	179	147	990	1137	51.3			160	371	344	853	1197	2.60
10	192	160	982	1142	39.4			165	373	346	851	1197	2.54
5	203	171	976	1147	31.8			170	375	348	849	1197	2.47
0	212	180	970	1150	26.8			175	377	351	847	1198	2.41
1	215	183	968	1151	25.2			180	380	353	845	1198	2.34
2	219	187	966	1153	23.5			185	382	355	843	1198	2.29
3	222	190	964	1154	22.3			190	384	358	841	1199	2.29
4	224	192	962	1154	21.4			195	386	360	839	1199	2.19
5	227	195	960	1155	20.1			200	388	362	837	1199	2.14
6	230	198	959	1157	19.4			205	390	364	836	1200	2.09
7	232	200	957	1157	18.7			210	392	366	834	1200	2.05
8	233	201	956	1157	18.4			215	394	368	832	1200	2.00
9	237	205	954	1159	17.1			220	396	370	830	1200	1.96
10	239	207	953	1160	16.5			225	397	372	828	1200	1.92
12	244	212	949	1161	15.3			230	399	374	827	1201	1.89
14	248	216	947	1163	14.3			235	401	376	825	1201	1.85
16	252	220	944	1164	13.4			240	403	378	823	1201	1.81
18	256	224	941	1165	12.6			245	404	380	822	1202	1.78
20	259	227	939	1166	11.9			250	406	382	820	1202	1.75
22	262	230	937	1167	11.3			255	408	383	819	1202	1.72
24	265	233	934	1167	10.8			260	409	385	817	1202	1.69
26	268	236	933	1169	10.3			265	411	387	815	1202	1.66
28	271	239	930	1169	9.85			270	413	389	814	1203	1.63
30	274	343	929	1272	9.46			275	414	391	812	1203	1.60
32	277	346	927	1273	9.10			280	416	392	811	1203	1.57
34	279	248	925	1173	8.75			285	417	394	809	1203	1.55
36	282	251	923	1174	8.42			290	418	395	808	1203	1.53
38	284	253	922	1175	8.08			295	420	397	806	1203	1.49
40	286	256	920	1176	7.82			300	421	398	805	1203	1.47
42	289	258	918	1176	7.57			305	423	400	803	1203	1.45
44	291	260	917	1177	7.31			310	425	402	802	1204	1.43
46	293	262	915	1177	7.14			315	426	404	800	1204	1.41
48	295	264	914	1178	6.94			320	427	405	799	1204	1.38
50	298	267	912	1179	6.68			325	429	407	797	1204	1.36
55	300	271	909	1180	6.27			330	430	408	796	1204	1.34
60	307	277	903	1180	5.84			335	432	410	794	1204	1.33
65	312	282	901	1183	5.49			340	433	411	793	1204	1.31
70	316	286	898	1184	5.18			345	434	413	791	1204	1.29
75	320	290	895	1185	4.91			350	435	414	790	1204	1.28
80	324	294	891	1185	4.67			355	437	416	789	1205	1.26
85	328	298	889	1187	4.44			360	438	417	788	1205	1.24
90	331	302	886	1188	4.24			365	440	419	786	1205	1.22
95	335	305	883	1188	4.05			370	441	420	785	1205	1.20
100	338	309	880	1189	3.89			375	442	421	784	1205	1.19
105	341	312	878	1190	3.74			380	443	422	783	1205	1.18
110	344	316	875	1191	3.59			385	445	424	781	1205	1.16
115	347	319	873	1192	3.46			390	446	425	780	1205	1.14
120	350	322	871	1193	3.34			395	447	427	778	1205	1.13
125	353	325	868	1193	3.23			400	448	428	777	1205	1.12
130	356	328	866	1194	3.12			450	460	439	766	1205	1.00
140	361	333	861	1194	2.92			500	470	453	751	1204	.89
145	363	336	859	1195	2.98			550	479	464	740	1204	.82
								600	489	475	728	1203	.74

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Standard Dimensions for Schedule 40 Pipe

Size (in)	Diameters		Nominal Thick-ness (in)	Circumference		Transverse Areas			Length of Pipe per sq ft		Length of Pipe Containing One Cubic Foot	Nominal Weight per foot		Number Threads per Inch of Screw
	External (in)	Approx-imate Internal (in)		External (in)	Internal (in)	External (sq in)	Internal (sq in)	Metal (sq in)	External Surface	Internal Surface		Plain Ends	Threaded and Coupled	
									Feet	Feet	Feet			
1/8	0.405	0.269	0.068	1.272	0.845	0.129	0.057	0.072	9.431	14.199	2533.775	0.244	0.245	27
1/4	0.540	0.364	0.088	1.696	1.114	0.229	0.104	0.125	7.073	10.493	1383.789	0.424	0.425	18
3/8	**0.675**	**0.493**	**0.091**	**2.121**	**1.549**	**0.358**	**0.191**	**0.167**	**5.658**	**7.747**	**754.360**	**0.567**	**0.568**	**18**
1/2	0.840	0.622	0.109	2.639	1.954	0.554	0.304	0.250	4.547	6.141	473.906	0.850	0.852	14
3/4	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.333	3.637	4.635	270.034	1.130	1.134	14
1	**1.315**	**1.049**	**0.133**	**4.131**	**3.296**	**1.358**	**0.864**	**0.494**	**2.904**	**3.641**	**166.618**	**1.678**	**1.684**	11½
1¼	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.669	2.301	2.767	96.275	2.272	2.281	11½
1½	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.799	2.010	2.372	70.733	2.717	2.731	11½
2	**2.375**	**2.067**	**0.154**	**7.461**	**6.494**	**4.430**	**3.355**	**1.075**	**1.608**	**1.847**	**42.913**	**3.652**	**3.678**	11½
2½	2.875	2.469	0.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	30.077	5.793	5.819	8
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	19.479	7.575	7.616	8
3½	**4.000**	**3.548**	**0.226**	**12.566**	**11.146**	**12.566**	**9.886**	**2.680**	**0.954**	**1.076**	**14.565**	**9.109**	**9.202**	**8**
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	3.174	0.848	0.948	11.312	10.790	10.889	8
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	4.300	0.686	0.756	7.198	14.617	14.810	8
6	**6.625**	**6.065**	**0.280**	**20.813**	**19.054**	**34.472**	**28.891**	**5.581**	**0.576**	**0.629**	**4.984**	**18.974**	**19.185**	**8**
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	8.399	0.442	0.478	2.878	28.554	28.809	8
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	11.908	0.355	0.381	1.826	40.483	41.132	8
12	**12.750**	**11.938**	**0.406**	**40.055**	**37.699**	**127.640**	**111.900**	**15.740**	**0.299**	**0.318**	**1.288**	**53.600**	—	—
14	14.000	13.125	0.437	43.982	41.217	153.940	135.300	18.640	0.272	0.280	1.069	63.000	—	—
16	16.000	15.000	0.500	50.265	47.123	201.050	176.700	24.350	0.238	0.254	0.817	78.000	—	—
18	**18.000**	**16.874**	**0.563**	**56.548**	**52.998**	**254.850**	**224.000**	**30.850**	**0.212**	**0.226**	**0.643**	**105.000**	—	—
20	20.000	18.814	0.593	62.831	59.093	314.150	278.000	36.150	0.191	0.203	0.519	123.000	—	—
24	24.000	22.626	0.687	75.398	71.063	452.400	402.100	50.300	0.159	0.169	0.358	171.000	—	—

Examples:

Warm up loss

Ambient Temp = 70°F

Working Temp = 366°F (150psig)

Warm up time = 720 minutes

1000 feet of 10 inch Schedule 40 pipe weighs = 40483

Latent heat = 857

$$Q = \frac{40483 \times (366-70) \times .12 \times 60}{857 \times 720}$$

Q = 472 lbs/hr

Radiation loss

Ambient Temp = 70°F
Working Temp = 366°F (150psig)
Differential temp = 294°F
Differential multiplier = .98
1000 feet 10 inch Schedule 40 uninsulated pipe
Latent heat = 857

$$Q = \frac{1000 \times 2600 \text{ (.98 [factor for 296° diff])}}{857}$$

Q = 2973 lbs/hr

Sizing for steam traps

$Q_t = Q_W + .5Q_R$

$.5Q_R = 1486.5 + Q_W = 472 = 1958.5$