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ICT

Understanding Steam Sterilizer Physical Parameters

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The Voice of Authority in Infection Control

Good sterilization monitoring practices are an essential part of any healthcare sterile processing quality assurance program. Much focus has been directed toward chemical and biological monitoring of sterilization cycles; however, the first monitors that should be utilized are the steam sterilizer physical (mechanical) monitors that are integral to the system itself. These include recorders, displays, digital printouts, and gauges that display and record time, temperature, and pressure parameters of the system.

These quality-assurance monitoring tools are often underutilized or misunderstood. They provide a means to ensure that appropriate parameters are met during a steam sterilization cycle. They also give operators a record of the sterilization cycle and a method for detecting sterilizer malfunctions or sterilizer operator error.

Although physical monitors are a common part of the sterilization-monitoring process and the information provided is an important component of sterilization record keeping, many sterilizer operators do not fully understand what the data on the recording devices are telling them. It is essential that sterilizer function be closely observed and understood to ensure that the conditions inside any sterilizing chamber meet the required sterilization parameters during its operating cycle.

Steam Sterilization Requirements

A number of factors must be considered for successful steam sterilization of instruments and medical devices to occur. Items must first be thoroughly cleaned, properly wrapped (if applicable), and positioned correctly in the sterilizer. The sterilizer itself must be functioning correctly, the quality of steam must be acceptable, and the proper cycle type selected for the items being processed. In addition, the appropriate time and temperature for the cycle must be selected based on the recommendations from the sterilizer manufacturer. Most importantly, the medical device manufacturer's reprocessing recommendations must be followed for each device being sterilized.

The microprocessors and computer printouts available on sterilizers today monitor and provide the operator with detailed information regarding each cycle run. The examples in Figure 1 are based on information available using this type of recording technology.

Steam Sterilizer Pressure and Exposure Temperature Relationship

The operator must be concerned about the relationship between the chamber temperature and pressure during a steam sterilization cycle,



because sterilization temperature will not be achieved without the necessary regulated steam pressure. Some sterilizer operators are confused by this relationship and reject loads because the sterilizer did not reach the pressure they felt was required.

Figure 1



From Century® Steam Sterilizer Operator Manual
129376-510, p.5-23, STERIS Corporation.

This situation has occurred because operators have been given temperature/pressure specifications that are based on published steam tables that have not been adjusted for the actual barometric pressure at the location where the sterilizer is being used. Often, the operators are given instructions to reject loads that have not achieved a minimum steam pressure of, for example, 30 pounds per square inch gauge (psig). A single pressure level of acceptance may be applicable to a sterilizer in one location but may not be correct for a sterilizer at another location. This can lead to errors in rejecting loads that are actually perfectly acceptable.

It is important to understand all the factors that contribute to a proper evaluation of chamber pressure: the meaning of the numbers listed in published steam tables, the difference between absolute pressure and gauge pressure, and the effect of local barometric pressure on gauge readings.

Most sterilizers have displays, gauges, and printouts that indicate gauge pressure. Gauge pressure and absolute pressure are *not* the same. Gauge pressure indicates pressure in excess of current atmospheric (barometric) pressure, whereas absolute pressure includes the current ambient pressure. In other words, gauge pressure would equal absolute pressure minus the ambient barometric pressure.

Figure 2 shows a saturated steam temperature table. The actual relationship between the temperature of saturated (100 percent) steam and chamber pressure has been well established by experimental means. Steam tables always list absolute pressure, not gauge pressure. For example, at a common sterilization temperature, 270 degrees C, the pressure shown on the steam table is 41.85 psi absolute.

When steam tables are used, a common mistake is to obtain a comparable gauge pressure by simply subtracting the barometric pressure found at sea level, which is a 14.7 psi difference. This would be correct only for equipment that is located at sea level and not for equipment at higher elevations, which have a lower barometric pressure.

To understand how atmospheric (barometric) pressure will affect the sterilizer in different locations, we will use two examples. For a hospital at sea level on the Florida coast, the barometric pressure would be about 14.7 psi. According to the steam tables, to achieve 270 degrees F (132 degrees C) requires 41.85 psi absolute pressure. To see what the gauge on the sterilizer would read at 270 degrees F (132 degrees C), subtract the barometric pressure from the absolute pressure (41.85 minus 14.7) and you get 27.15 psi gauge pressure. Note that most sterilizers operate at a slightly higher temperature than set point (about 2 to 3 degrees F above) which requires approximately one or two psi more steam, resulting in a gauge reading of about 29 psi.

The next example will be for a sterilizer in Denver, which is approximately a mile above sea level and has a barometric pressure of about 11

psi. To reach 270 degrees F (132 degrees C) still requires 41.85 psi absolute, but since the barometric pressure is lower, the sterilizer gauge would read a different number (41.85 minus 11, or 30.85). Again the sterilizer runs the same 2 to 3 degrees F above set point, and adding the same couple of psi as in the previous example results in a gauge pressure of about 33 psi. This is almost four psi higher than the same sterilizer operating in Florida.

Note that barometric pressure differences are not the only factor that affects the pressure required to achieve sterilization temperature. The steam tables are based on steam that is saturated, or 100 percent quality. Lesser steam quality, which is more typical, will require an even higher chamber pressure. You must have 50 psig to 80 psig of dynamic steam pressure coming from the steam source which is then regulated for your sterilization needs at the sterilizer.

Because of the variances described above and the impracticality of expecting operators to interpret barometric pressures and steam quality, a more practical way to understand

what is typical for your specific sterilizer is to review your sterilizer recording devices, establish an average pressure and temperature for a particular sterilizer, and use that as a standard. If an operator observes pressures that vary by more than plus or minus 2 psi, it may be an indication that the unit calibration should be checked.

Steam pressure must be increased by a half pound for every 1,000 feet above sea level to achieve sterilization temperature; therefore, if Denver is 5,000 feet above sea level, the sterilizer may have to be adjusted by a service technician to achieve the higher operating pressure.

As you can see, atmospheric pressure alone will have a dramatic effect on a sterilizer's required steam pressure, as will differences in steam quality. Therefore, a standardized published listing of 30 psi as the correct pressure needed for a 270 degrees F (132 degrees C) cycle is not accurate or useful to sterilizer operators.

Understanding Prevacuum (Prevac) Sterilizer Readings

In vacuum-assisted steam sterilizers there are three phases of the cycle with which operators should be familiar: the conditioning, sterilizing, and exhaust (drying) phases.*

Conditioning phase: During the conditioning phase (a "C" prints on the paper tape) the unit goes through alternating pressure and vacuum pulses (prevac cycle). The pressure pulse will always be the same — 26 psig. This is controlled by a pressure switch setting. The vacuum pulse must reach a minimum of 10 inches of mercury (Hg), and when fully

*This equipment description applies to Amsco brand equipment from STERIS Corporation. Other manufactured equipment may not be the same and the manufacturer should be consulted.

Figure 2

VAPOUR PRESSURE OF WATER					
Atmos. Pressure			Atmos. Pressure		
Temperature	Pressure	Height	Temperature	Pressure	Height
°F	inches	feet	°F	inches	feet
86	0.486	0.262	100	1.013	0.550
88	0.507	0.274	102	1.037	0.564
90	0.529	0.286	104	1.062	0.578
92	0.552	0.299	106	1.087	0.592
94	0.576	0.312	108	1.113	0.606
96	0.601	0.325	110	1.140	0.620
98	0.627	0.338	112	1.167	0.634
100	0.654	0.351	114	1.195	0.648
102	0.682	0.364	116	1.224	0.662
104	0.711	0.377	118	1.253	0.676
106	0.741	0.390	120	1.283	0.690
108	0.772	0.403	122	1.314	0.704
110	0.804	0.416	124	1.345	0.718
112	0.837	0.429	126	1.377	0.732
114	0.871	0.442	128	1.410	0.746
116	0.906	0.455	130	1.443	0.760
118	0.942	0.468	132	1.477	0.774
120	0.979	0.481	134	1.511	0.788
122	1.017	0.494	136	1.546	0.802
124	1.056	0.507	138	1.581	0.816
126	1.096	0.520	140	1.617	0.830
128	1.137	0.533	142	1.653	0.844
130	1.179	0.546	144	1.690	0.858
132	1.222	0.559	146	1.727	0.872
134	1.266	0.572	148	1.765	0.886
136	1.311	0.585	150	1.803	0.900
138	1.357	0.598	152	1.842	0.914
140	1.404	0.611	154	1.881	0.928
142	1.452	0.624	156	1.921	0.942
144	1.501	0.637	158	1.961	0.956
146	1.551	0.650	160	2.002	0.970
148	1.602	0.663	162	2.043	0.984
150	1.654	0.676	164	2.085	0.998
152	1.707	0.689	166	2.127	1.012
154	1.761	0.702	168	2.170	1.026
156	1.816	0.715	170	2.213	1.040
158	1.872	0.728	172	2.257	1.054
160	1.929	0.741	174	2.301	1.068
162	1.987	0.754	176	2.346	1.082
164	2.046	0.767	178	2.391	1.096
166	2.106	0.780	180	2.437	1.110
168	2.167	0.793	182	2.483	1.124
170	2.229	0.806	184	2.530	1.138
172	2.292	0.819	186	2.577	1.152
174	2.356	0.832	188	2.625	1.166
176	2.421	0.845	190	2.673	1.180
178	2.487	0.858	192	2.721	1.194
180	2.554	0.871	194	2.770	1.208
182	2.622	0.884	196	2.819	1.222
184	2.691	0.897	198	2.869	1.236
186	2.761	0.910	200	2.919	1.250
188	2.832	0.923	202	2.970	1.264
190	2.904	0.936	204	3.021	1.278
192	2.977	0.949	206	3.072	1.292
194	3.051	0.962	208	3.124	1.306
196	3.126	0.975	210	3.176	1.320
198	3.202	0.988	212	3.229	1.334
200	3.279	1.001	214	3.282	1.348
202	3.357	1.014	216	3.336	1.362
204	3.436	1.027	218	3.390	1.376
206	3.516	1.040	220	3.445	1.390
208	3.597	1.053	222	3.500	1.404
210	3.679	1.066	224	3.556	1.418
212	3.762	1.079	226	3.612	1.432
214	3.846	1.092	228	3.669	1.446
216	3.931	1.105	230	3.726	1.460
218	4.017	1.118	232	3.784	1.474
220	4.104	1.131	234	3.842	1.488
222	4.192	1.144	236	3.901	1.502
224	4.281	1.157	238	3.960	1.516
226	4.371	1.170	240	4.020	1.530
228	4.462	1.183	242	4.080	1.544
230	4.554	1.196	244	4.141	1.558
232	4.647	1.209	246	4.202	1.572
234	4.741	1.222	248	4.264	1.586
236	4.836	1.235	250	4.326	1.600
238	4.932	1.248	252	4.389	1.614
240	5.029	1.261	254	4.452	1.628
242	5.127	1.274	256	4.516	1.642
244	5.226	1.287	258	4.580	1.656
246	5.326	1.300	260	4.645	1.670
248	5.427	1.313	262	4.710	1.684
250	5.529	1.326	264	4.776	1.698
252	5.632	1.339	266	4.842	1.712
254	5.736	1.352	268	4.909	1.726
256	5.841	1.365	270	4.976	1.740
258	5.947	1.378	272	5.044	1.754
260	6.054	1.391	274	5.112	1.768
262	6.162	1.404	276	5.181	1.782
264	6.271	1.417	278	5.251	1.796
266	6.381	1.430	280	5.321	1.810
268	6.492	1.443	282	5.392	1.824
270	6.604	1.456	284	5.463	1.838
272	6.717	1.469	286	5.535	1.852
274	6.831	1.482	288	5.607	1.866
276	6.946	1.495	290	5.680	1.880
278	7.062	1.508	292	5.753	1.894
280	7.179	1.521	294	5.827	1.908
282	7.297	1.534	296	5.901	1.922
284	7.416	1.547	298	5.976	1.936
286	7.536	1.560	300	6.051	1.950
288	7.657	1.573	302	6.127	1.964
290	7.779	1.586	304	6.203	1.978
292	7.902	1.599	306	6.280	1.992
294	8.026	1.612	308	6.357	2.006
296	8.151	1.625	310	6.435	2.020
298	8.277	1.638	312	6.513	2.034
300	8.404	1.651	314	6.592	2.048
302	8.532	1.664	316	6.671	2.062
304	8.661	1.677	318	6.751	2.076
306	8.791	1.690	320	6.831	2.090
308	8.922	1.703	322	6.912	2.104
310	9.054	1.716	324	6.993	2.118
312	9.187	1.729	326	7.075	2.132
314	9.321	1.742	328	7.157	2.146
316	9.456	1.755	330	7.240	2.160
318	9.592	1.768	332	7.323	2.174
320	9.729	1.781	334	7.407	2.188
322	9.867	1.794	336	7.491	2.202
324	10.006	1.807	338	7.576	2.216
326	10.146	1.820	340	7.661	2.230
328	10.287	1.833	342	7.747	2.244
330	10.429	1.846	344	7.833	2.258
332	10.572	1.859	346	7.920	2.272
334	10.716	1.872	348	8.007	2.286
336	10.861	1.885	350	8.095	2.300
338	11.007	1.898	352	8.183	2.314
340	11.154	1.911	354	8.272	2.328
342	11.302	1.924	356	8.361	2.342
344	11.451	1.937	358	8.451	2.356
346	11.601	1.950	360	8.541	2.370
348	11.752	1.963	362	8.632	2.384
350	11.904	1.976	364	8.723	2.398
352	12.057	1.989	366	8.815	2.412
354	12.211	2.002	368	8.907	2.426
356	12.366	2.015	370	9.000	2.440
358	12.522	2.028	372	9.093	2.454
360	12.679	2.041	374	9.187	2.468
362	12.837	2.054	376	9.281	2.482
364	12.996	2.067	378	9.376	2.496
366	13.156	2.080	380	9.471	2.510
368	13.317	2.093	382	9.567	2.524
370	13.479	2.106	384	9.663	2.538
372	13.642	2.119	386	9.760	2.552
374	13.806	2.132	388	9.857	2.566
376	13.971	2.145	390	9.955	2.580
378	14.137	2.158	392	10.053	2.594
380	14.304	2.171	394	10.152	2.608
382	14.472	2.184	396	10.252	2.622
384	14.641	2.197	398	10.352	2.636
386	14.811	2.210	400	10.453	2.650
388	14.982	2.223	402	10.554	2.664
390	15.154	2.236	404	10.656	2.678
392	15.327	2.249	406	10.758	2.692
394	15.501	2.262	408	10.861	2.706
396	15.676	2.275	410	10.964	2.720
398	15.852	2.288	412	11.068	2.734
400	16.029	2.301	414	11.172	2.748
402	16.207	2.314	416	11.277	2.762
404	16.386	2.327	418	11.382	2.776
406	16.566	2.340	420	11.488	2.790
408	16.747	2.353	422	11.594	2.804
410	16.929	2.366	424	11.701	2.818
412	17.112	2.379	426	11.808	2.832
414	17.296	2.392	428	11.916	2.846
416	17.481	2.405	430	12.024	2.860
418	17.667	2.418	432	12.133	2.874
420	17.854	2.431	434	12.242	2.888
422	18.042	2.444	436	12.352	2.902
424	18.231	2.457	438	12.462	2.916
426	18.421	2.470	440	12.573	2.930
428	18.612	2.483	442	12.684	2.944
430	18.804	2.496	444	12.795	2.958
432	19.007	2.509	446	12.907	2.972
434	19.211	2.522	448	13.019	2.986
436	19.416	2.535	450	13.132	2.999
438	19.622	2.548	452	13.245	3.013
440	19.829	2.561	454	13.359	3.027
442	20.037	2.574	456	13.473	3.040
444	20.246	2.587	458	13.588	3.054
446	20.456	2.600	460	13.703	3.068
448	20.667	2.613	462	13.818	3.081
450	20.879	2.626	464	13.934	3.095
452	21.092	2.639	466	14.050	3.109
454	21.306	2.652	468	14.166	3.122
456	21.521	2.665	470	14.283	3.136
458	21.737	2.678	472	14.400	3.150
460	21.954	2.691	474	14.517	3.163
462	22.172	2.704	476	14.635	3.177
464	22.391	2.717	478	14.753	3.190
466	22.611	2.730	480	14.872	3.204
468	22.832	2.743	482	14.991	3.218
470	23.054	2.756	484	15.111	3.231
472	23.277	2.769	486	15.231	3.245
474	23.501	2.782	488	15.352	3.259
476	23.726	2.795	490	15.473	3.272
478	23.952				