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GUIDELINES FOR SIZING WATER HEATERS

California Conference of Directors of Environmental Health

I. BACKGROUND

A critical factor in preventing foodborne illnesses in a food facility is the provision of an adequate supply of hot water for the washing of hands, utensils, equipment, and the facility itself. The installation of a properly sized water heater will ensure that a sufficient amount of hot water will be available at all times.

II. PURPOSE

The purpose of these guidelines is to provide a set of criteria that will assist architects, designers, contractors, and owners in properly sizing water heaters to adequately meet the anticipated hot water demands of food facilities in California.

Food facilities with water heaters sized according to these criteria should be capable of complying with the requirements for providing an adequate hot water supply as required by the California Retail Food Code.

III. LEGAL AUTHORITY

California Health and Safety Code, Division 104, Part 7.

IV. DEFINITIONS

A. **Booster Heater:** An instantaneous water heater designed and intended to raise the temperature of hot water to a higher temperature for a specific purpose, such as for the sanitizing rinse on a high temperature automatic dishmachine.

B. **BTU (British Thermal Unit):** The quantity of heat required to raise the temperature of one pound of water one (1) degree Fahrenheit.

C. **GPH (Gallons Per Hour):** The amount of water, in gallons, that is capable of being used each hour by the plumbing fixtures and equipment, such as dishmachines.

D. **GPM (Gallons Per Minute):** The amount of water, in gallons, capable of flowing through a plumbing fixture or through an instantaneous water heater per minute.

E. **Instantaneous Water Heater:** A water heater that generates hot water on demand.

F. **KW (Kilowatt):** A unit of electric power equal to 1,000 watts.

G. **Rise:** The temperature of water as it leaves the water heater minus the temperature of the water entering the water heater.

H. **Storage Water Heater:** A water heater that incorporates a thermostat, a storage tank, and a burner or heating elements, to heat and maintain the water within the tank at a specific temperature.

I. **Thermal Efficiency:** The measure of the overall efficiency of the water heater, taking into consideration loss of energy due to combustion, radiation, convection, and conduction of heat from the unit.

V. GENERAL REQUIREMENTS

A. A water heater shall be provided which is capable of generating an adequate supply of hot water, at a temperature of at least 120°Fahrenheit (F), to all sinks, janitorial facilities, and other equipment and fixtures that use hot or warm water, at all times.

B. Water heaters and their installation must be in compliance with all local building code requirements.

C. Water heaters that use reclaimed heat from equipment to heat water shall be evaluated on a case by case basis.

VI. SIZING REQUIREMENTS FOR STORAGE WATER HEATERS

A. For food facilities that utilize multiservice eating and drinking utensils, the water heater shall have a recovery rate equal to or greater than 100% of the computed hourly hot water demand, in GPH.

B. For food facilities that use only single-service eating and drinking utensils, or don't use utensils at all, the water heater shall have a recovery rate equal to or greater than 80% of the computed hourly hot water demand, in GPH.

C. For food facilities that handle and sell only prepackaged foods, a water heater with a minimum storage capacity of ten gallons shall be provided.

D. The hourly hot water demand for the food facility, in GPH, is calculated by adding together the estimated hot water demands for all sinks and other equipment, such as dishmachines, which utilize hot water. The estimated hot water demands for sinks and other equipment that utilize hot water are listed in Appendix I. The hot water demands for automatic warewashers, such as dishmachines, glasswashers, and potwashers are found in the listing established by a nationally recognized testing laboratory for that particular piece of equipment.

E. The following examples are provided to explain how to calculate the total hourly hot water demand:

1. Food facility that utilizes only **single service** eating and drinking utensils, assume:

Quantity	Sink Type	Demand
1	Three compartment sink (18”x18”)	42 GPH
2	Hand lavatories	10 GPH (5 GPH each)
1	Janitorial sink	15 GPH
	Total	**67 GPH**

67 GPH X 80% allowance for single service utensils = **54 GPH**. For the food facility in this example, a water heater would be required which will recover **54 GPH**.

2. Food facility that utilizes **multiservice** eating and drinking utensils, assume:

Quantity	Sink Type	Demand
1	Three compartment sink (18”x18”)	42 GPH
1	Automatic dishmachine	80 GPH
1	Hand spray	45 GPH
1	Food prep sink	5 GPH
2	Hand lavatories	10 GPH (5 GPH each)
1	Janitorial sink	15 GPH
	Total	**197**

Since the food facility in this example uses multiservice eating and drinking utensils, 100% of the computed hourly hot water demand must be provided. Therefore, a water heater would be required which will recover 197 GPH.

F. To compute a BTU or KW rating for the required hourly hot water demand found in example #1, the following formulas should be used:

Formula 1 (for gas water heaters):

$$BTU\ Input = GPH\ X\ °\text{F}\ Rise^{1}\ X\ \frac{8.33lb}{gallon} \div Thermal\ Efficiency^{2}$$

BTU Input = 54 GPH X 60°F X 8.33 lbs./gallon / 0.75 = 35,986 BTU

[1] The average temperature of tap water varies throughout the State depending upon the location, elevation, and time of year. In order to properly size the water heater check with your local health agency to determine the required rise. For the purposes of these guidelines, a tap water temperature of 60°F will be used. Therefore, to achieve a temperature of 120°F at the faucet, the required rise would be 60°F.

[2] The thermal efficiency for gas water heaters, unless otherwise listed by a nationally recognized testing laboratory, will be assumed to be 75%.

Formula 2 (for electric water heaters):

$$KW\ input = GPH\ X\ °\text{F}\ Rise\ X\ \frac{8.33lb}{gallon\ of\ water} \div\ Thermal\ Efficiency^{1}\ X\ 3412\frac{BTU}{KW}$$

KW input = 54 GPH X 60°F X 8.33 lbs. / 0.98 X 3412 BTU/KW = 8.1 KW

[1] The thermal efficiency for electric water heaters, unless otherwise listed by NSF International or other nationally recognized testing laboratories, will be assumed to be 98%.

Sizing tables for gas and electric water heaters are found in Appendices II and III respectively.

VII. SIZING REQUIREMENTS FOR TANKLESS/INSTANTANEOUS WATER HEATERS

A. INTRODUCTION

Tankless (instantaneous) water heaters produce hot water by passing water through a heat exchanger. For proper heating of the water, water must flow through the tankless water heater slowly to allow for adequate heat transfer from the heat exchanger to the water. Therefore, the quantity, or rate at which the hot water is delivered can be significantly less than that provided by a storage water heater. Tankless water heater flow rates are measured in GPM.

B. SIZING AND CONFIGURATION

1. Food facilities with improperly sized tankless water heater systems will not be able to provide the minimum hot water flow rate required when multiple plumbing fixtures and/or pieces of equipment require hot water simultaneously. An example of this is when multiple fixtures in use at a food facility cause the pressure **(PSI)** of the hot water line feeding a dishmachine to fall below the required pressure for that machine. When this occurs, an inadequate quantity of hot water may be dispensed during the machine's wash and/or rinse cycles, which may lead to improper warewashing and possible cross-contamination.
2. Consequently, facilities with high hot water demand may be required to install multiple tankless water heaters and/or equipment booster heaters. Also, facilities with dishmachines that require minimum hot water pressure rates and do not have internal pressure gauges that measure incoming hot water flow, may be required to install pressure gauges at hot water lines feeding dishmachines. Gauges must be installed according to dishmachine manufacturer's recommendations/guidelines and applicable plumbing codes.

C. TEMPERATURE RISE

The flow rate of hot water that a tankless water heater can provide is also affected by the temperature of the incoming water at the food facility. Colder incoming water will require the tankless water heater to provide more heat to the incoming water, which will lower the flow rate of hot water that the tankless water heater can provide. Whereas storage water heaters have reserve supplies of hot water to mediate the effects of high degree rise requirements at a food facility, tankless water heater system don't have this safe-guard.

D. LOW FLOW FIXTURES

The ability of a tankless water heater system to provide hot water may also be compromised where there are low flow fixtures at a facility. When low flow fixtures are present at a facility these fixtures may not activate the tankless water heater system because the hot water demand of the fixture(s) is below the activation rate of the tankless water heaters . The minimum activation rate of some tankless water heaters can be 0.4 GPM or higher. Where low flow fixtures are utilized or required at a facility, facilities with tankless water heaters may need to provide hot water recirculation system and/or point-of-use water heaters. Local health jurisdictions may prohibit tankless water heaters with high minimum activation rates, for example, units with rates of 0.5 GPM or higher.

E. THE COLD WATER SANDWICH EFFECT

The 'cold water sandwich effect' is another factor that must be taken into account when considering the installation of a tankless water heater. The 'cold water sandwich effect' is a condition where cold water is fed into a facility's hot water lines while the tankless water heater's **heat exchanger** is heating up. This delay in providing hot water by the tankless water heater can result in 10 to 30 seconds of cold water being fed into the hot water lines at a facility while the heat exchanger is heating up. When this occurs, equipment and fixtures with low hot water demand, such as low water demand dishmachines and hand sinks, may not receive the quantity of hot water that they require for proper operation. Facilities with low water demand dishmachines or faucets may be required to install hot water recirculation systems, booster heaters, and/or point-of-use water heaters to ensure that a consistent supply of hot water is available for all of the fixtures and equipment at their facility.

F. WATER QUALITY AND MAINTENANCE

Other factors to consider when evaluating the benefits and costs of installing a tankless water heater system are water quality and maintenance. In areas with hard water, tankless water heater manufacturers, as part of the warranty, may require pre-treatment of the incoming water to the tankless water heater. Manufacturers may also require regular maintenance of the heater to remove scale and lime deposits and for cleaning and flushing of any required filter(s).

G. ELECTRIC TANKLESS / INSTANTANEOUS WATER HEATERS

Local health jurisdictions may limit or prohibit the use of electric tankless water heaters at licensed food facilities due to the low flow rate that these units can provide and the lack of durability that has been observed in many of these types of units. Where very low flow rates are required, such as in some satellite food facilities, at restrooms (hand sinks), and at single fixtures or pieces of equipment, local health jurisdictions may approve the use of electric tankless water heaters. Note: The minimum activation rate for the electric tankless water heater must be lower than the maximum flow rate for each fixture that is fed by the tankless water heater. A tank water heater may be required when low flow rate fixtures/aerators are used.

H. FIXTURE FLOW REQUIREMENTS

Tankless water heaters must be sized to provide hot water of at least 120°F at a rate of at least two GPM to each fixture at a facility. Therefore, warewashing sinks that have multiple faucets will be required to be supplied with 2 GPM per faucet. Hand lavatories and facility dump sinks are required to be provided with at least ½ GPM per faucet. Note: Actual fixture flow rates may exceed the estimated rates listed in the sizing guidelines. Where rates are higher than the guidelines, alterations may be required to a facility's hot water system to ensure an adequate supply of hot water is available at that facility.

I. EQUIPMENT FLOW REQUIREMENTS

The minimum required flow rates for equipment, such as dishmachines and glass washers, can be determined by referencing the NSF listings for the piece of equipment specified, by checking the listings of other established nationally recognized testing laboratories and/or by checking the manufacturer's specifications. Dishmachine and glass washer minimum required flow rates can also be determined by dividing the length of time of the rinse cycle (in seconds) into 60 seconds and then multiplying that number by the quantity of hot water required during the rinse cycle (see formula listed below).

Formula 3 (hot water demand for dishmachines):

$$GPM\ Demand = \frac{60\ seconds/min}{rinse\ cycle\ time\ (sec)}\ x\ (quanity\ of\ hot\ water\ required\ during\ rinse\ cycle\{gal\})$$

Flow Requirements for Facilities w/ Tankless Water Heaters	
Fixture Type	**Minimum Flow Requirement**
Hand Lavatories	0.5 GPM
Dump Sink	0.5 GPM
Warewashing Sink	2.0 GPM (per faucet at sink)
Food Preparation Sink	2.0 GPM
Janitorial Sink	2.0 GPM
Dishmachine / Glass Washer	See ANSI accredited certification program listing, manufacturer's documentation, and/or formula listed in this guide.
Other Equipment	See ANSI accredited certification program listing and/or manufacturer's documentation.

i. Example #1

Food facility with two hand sinks in the kitchen and one hand sink in each restroom for a total of four hand sinks. There is a warewashing sink with one faucet, a janitorial sink, and a food preparation sink. Facility has a low temperature dishmachine that requires a flow rate of 4.3 GPM and incoming hot water pressure of 15 psi to 25 psi according to its NSF listing. The local health agency uses a 60°F rise for their calculations based on incoming water temperatures. The tankless water heater proposed for this facility is a gas tankless water heater that has a maximum input of 199,000 BTU/H. At a 60°F rise, this water heater is able to provide a maximum flow rate of 5.6 GPM.

Quantity	Fixture Type	Demand (GPM)
4	Hand lavatories	2
1	Warewashing sink (1 faucet)	2
1	Food Preparation Sink	2
1	Janitorial Sink	2
1	Dishmachine	4.3
	Total:	**12.3**

In example #1 above, the facility has a hot water flow requirement of 12.3 GPM. The proposed water heater has a maximum flow rate of 5.6 GPM. Therefore, three of the proposed tankless water heaters would be required at this facility. (See "Installation Requirements" below).

ii. Example #2

Food facility has three hand sinks in the kitchen, two hand sinks in the restrooms, and one hand sink at front bar area. Facility has a bar sink that has one faucet and a warewashing sink with two faucets. Facility also has a janitorial sink, a bar dump sink, and a food preparation sink. Facility also has a high temperature dishmachine that requires minimum final rinse temperature of 180°F. The flow rate requirement for the dishmachine is 4.8 GPM.

This facility has a glass washer at its bar. This glass washer has a rinse time of 32 seconds and 1.7 gallons of hot water being delivered during the rinse cycle. This glass washer has its highest water demand during the rinse cycle, so the required flow rate for this glass washer can be calculated by dividing the length of the rinse cycle (in seconds) into 60 seconds and then multiplying by the gallons of hot water required during the rinse cycle. So, the required flow rate for this glass washer equals [(60 / 32) X 1.7] which is 3.2 GPM.

The local health agency uses a 60°F rise for their calculations based on incoming water temperatures at this facility. The tankless water heater proposed for this facility is a gas tankless water heater that has a maximum input of 199,000 BTU/H. At a 60°F rise, this water heater is able to provide a flow rate of 7.7 GPM.

Quantity	Fixture Type	Demand (GPM)
6	Hand lavatories	3
1	Warewashing sink (2 faucet)	4
1	Bar sink	2
1	Food Preparation sink	2
1	Dump sink	0.5
1	Janitorial sink	2
1	Dishmachine	4.8
1	Glass Washer	3.2
	Total:	**21.5**

In example #2 above, the facility has a hot water flow requirement of 21.5 GPM. The tankless water heater proposed is able to provide 7.7 GPM of 120°F water. Therefore, three of the proposed tankless water heaters would be required (See “Installation Requirements” below). Also, the dishmachine would be required to have a booster heater that is capable of boosting the 120°F incoming water to at least 180°F.

VIII. REQUIREMENTS FOR BOOSTER HEATERS

A. When a hot water sanitizing warewashing machine is used, a booster heater must be provided that will raise the incoming general purpose hot water up to at least 180°F for the final sanitizing rinse cycle.

B. When sizing a booster heater, the hot water demand for the warewashing final sanitizing rinse cycle should be obtained from the NSF International listings or listings established by other nationally recognized testing laboratories.

C. The formulas for calculating BTU or KW input listed in Section VI., Line F should be used when determining the minimum required size for a booster heater.

D. When a booster heater is installed below a drainboard, it shall be installed at least six inches above the floor, away from the wall, and in a manner that will allow accessibility for proper cleaning and servicing.

IX. RECIRCULATION PUMPS

A. Where fixtures are located more than sixty feet from the water heater, a recirculation pump must be installed in order to ensure that water reaches the fixture at a temperature of at least 120°F.

B. In some cases it may be more practical to install a separate, smaller water heater for remote fixtures, such as for restroom handsinks.

X. INSTALLATION REQUIREMENTS

A. Where feasible, water heaters should be located in an area of the food facility separated from all food and utensil handling areas.

B. The Uniform Building Code prohibits the installation of gas water heaters in restrooms or change rooms.

C. Water heaters shall be mounted in one of the following manners:
   1. On six inch high, easily cleanable legs.
   2. On a four inch high coved curb base. All openings between the water heater and the base must be sealed in a watertight manner.
   3. On a properly finished and installed wall pedestal, positioned so that it is out of the work and traffic space.
   4. In an easily accessible location above a suspended ceiling. Where a permanently installed ladder is required to access the water heater, the ladder shall not be installed above a food or utensil handling area.
   5. Note: The local health agency may allow alternate installation methods when a water heater is installed in an area separated from food and utensil handling areas, such as in a mechanical room.

D. A common mistake with electric water heaters is the ordering and installing of a water heater with an upper element of 4500 watts, a lower element of 4500 watts, and a total connected (or maximum) wattage of 4500 watts. On such a water heater, only one element is operating. Many individuals do not observe the total connected wattage and assume that because each of the elements is 4500 watts, their water heater has an input rating of 9000 watts. Water heater manufacturers have specific procedures for rewiring an electric water heater so that the upper and lower elements are operating simultaneously. Some manufacturers only permit rewiring in the factory. Field modifications will normally void warranties and any listings that the unit comes with. Prior to acceptance of a field modified water heater, the local health agency should ensure that the modifications were performed according to the manufacturer's recommendations and with the approval of the local building officials. The data plate on a field modified water heater must be changed to reflect the total connected wattage rating with both elements operating simultaneously.

E. When multiple water heaters are connected, they must be installed in parallel, not in a series (See Appendix IV).

Appendix I

Hourly Hot Water Demand Table

Utensil Sink			
Compartment Size	**Gallons Per Compartment**	**Compartment Size**	**Gallons Per Compartment**
16” X 20”→	14	18” X 30”→	23
18” X 18”→	14	20” X 28”→	24
18” X 24”→	19	24” X 24”→	25
18” X 26”→	20	24” X 30”→	31

Dishmachines/Glasswashers:	Refer to manufacturer specs for GPH and minimum water temperature inputs
Bar Sink (12” X 12”):	6 gallons per compartment
Food Prep Sink:	5 gallons per compartment
Janitorial Sink:	15 gallons per sink
Garbage Can Wash Facility:	15 gallons per facility
Hand sink(s):	5 gallons per sink
Pre-Rinse Hand Spray:	45 gallons (if other type, refer to manufacture specifications)
Clothes Washer:	
9 & 12 pound washers	45 gallons
16 pound washers	60 gallons
Employee Shower:	20 gallons
For all others:	Refer to manufacturer specifications

Appendix II

Sizing Table for Gas Water Heaters

Gallons per Hour Delivery at Indicated Temperature Rise

BTU (X1000)	40°F	50°F	60°F	70°F
5	11	9	8	6
10	23	18	15	13
15	34	27	23	19
20	45	36	30	26
25	56	45	38	32
30	68	54	45	39
35	79	63	53	45
40	90	72	60	54
45	101	81	68	58
50	113	90	75	64
55	124	99	83	71
60	135	108	90	77
65	146	117	98	84
70	158	126	105	90
75	169	135	113	96
80	180	144	120	103
85	191	153	128	109
90	203	162	135	116
95	214	171	143	122
100	225	180	150	129
105	236	189	158	135
110	248	198	165	141
115	259	207	173	148
120	270	216	180	154
125	281	225	188	161
130	293	234	195	167
135	304	243	203	174
140	315	252	210	180
145	326	261	218	187
150	338	270	225	193
155	349	279	233	199
160	360	288	240	206
165	371	297	248	212
170	383	306	255	219
175	394	315	263	225
180	405	324	270	232
185	416	333	278	238
190	428	342	285	244
195	439	351	293	251
200	450	360	300	257
205	461	369	308	264
210	473	378	315	270
215	484	387	323	277
220	495	396	330	283
225	516	405	338	289
230	518	414	345	296
235	529	423	353	302
240	540	432	360	309
245	551	441	368	315
250	563	450	375	322

Appendix III

Sizing Table for Electric Water Heaters

Gallons per Hour Delivery at Indicated Temperature Rise

KW	40°F	50°F	60°F	70°F
1	10	8	7	6
2	20	16	13	11
3	30	24	20	17
4	40	32	27	23
5	50	40	33	29
6	60	48	40	34
7	70	56	47	40
8	80	64	54	46
9	90	72	60	52
10	100	80	67	57
11	110	88	74	63
12	120	96	80	69
13	130	104	87	75
14	141	112	94	80
15	151	120	100	86
16	161	128	107	92
17	171	136	114	97
18	181	145	120	103
19	191	153	127	109
20	201	161	134	115
21	211	169	141	120
22	221	177	147	126
23	231	185	154	132
24	241	193	161	138
25	251	201	167	143
26	261	209	174	149
27	271	217	181	155
28	281	225	187	161
29	291	233	194	166
30	301	241	201	172
31	311	249	207	178
32	321	257	214	184
33	33	265	221	189
34	341	273	227	195
35	351	281	234	201
36	361	289	241	206
37	371	297	248	212
38	381	305	254	218
39	391	313	261	224
40	401	321	268	229
41	411	329	274	235
42	422	337	281	241
43	432	345	288	247
44	442	353	294	252
45	452	361	301	258
46	462	369	308	264
47	472	377	314	270
48	482	385	321	275
49	492	393	328	281
50	502	401	335	287

Appendix IV

Water Heaters Installed In Parallel