



## Use of Steam in Bread & Roll Ovens

By Joseph P. Day, President

Regularly we focus on the performance of the baker's ovens, addressing a variety of performance questions and challenges. This article focuses on a thermal aspect of the baker's process that gets only modest attention – steam.

One of the supplemental processes to bread and roll baking is steaming in the ovens. Historically, this has been more of an art than a science and over the years techniques for using steam in the baking process have been passed on from baker to baker.

### **Why Steam?**

Steam is generally used by the baker to provide a glossy surface to the crust and to avoid cracking the crust during the bake.

Important quality considerations for the baker, gloss and cracking are contingent on ingredients and recipe used combined with effective oven operation balanced with appropriate amounts and consistency of steam.

### **Types of Steam:**

Bakers refer to steam used in the bakery in a wide variety of ways including – wet, dry, soft, hard and more. There are, however, two distinctly different steams produced in boilers:

- Dry Saturated Steam – steam at the temperature of the boiling point of water corresponding to its pressure (212°F @ 0 psig; 240°F @ 10 psig) and does not contain water held in suspension mechanically.
- Super Heated Steam – steam heated to a temperature higher than the boiling point corresponding to its pressure (250°F steam @ 10 psig equals a 240°F boiling point plus 10°F of superheat). Super heated steam can not exist in contact with water, nor contain water and resembles a perfect gas.

The “quality” of saturated steam can vary based on the volume of water droplets contained in the steam. The highest quality steam contains no water droplets, pure (100% “quality”) steam. If the steam contains water droplets, referred to as entrained moisture, for example 5% entrained moisture, the “quality” is referenced as 95%, i.e. 95% dry saturated steam and 5% moisture. When heat is added the moisture is converted to steam and eventually becomes 100% dry steam. Should heat continue to be added (in the absence of water) the dry steam becomes super heated steam. Dry saturated steam with entrained moisture is typically referred to as “wet steam”.

Often misunderstood is the fact that dry saturated steam and super heated steam are not visible. The water is in the form of an invisible vapor or “gas”. It is only when either form is cooled that the water vapor condenses into minute water droplets, forming a visible mist or fog.

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Here are perspectives of two key functions in the bakery:

<b><i>Baker</i></b>	<b><i>Engineer</i></b>
Dry Steam	Dry saturated steam
Wet Steam	Dry saturated steam with entrained water
Hard Steam	Super heated steam
Soft Steam	Dry super heated steam with entrained water
Gaseous Steam	All steam is gaseous

In the overall use of steam in the baking process, steam pressures must be considered. Low-temperature and consequently low-pressure steam is by far the best and easiest steam to use in bread and roll ovens; typically 2 to 5 psig at the oven. Realizing that boiler steam at 10 psig and 240° F when reduced to 2 psig (218°F boiling point) still has 22°F of superheat, boiler pressures should be maintained as low as possible while still being able to deliver necessary quantities to the oven. Further, provisions must be made to eliminate the superheat resulting from the reduction in steam pressure.

An early study by Dr. Lloyd Brownell resulted in important considerations for the baker using steam. These considerations are:

- 1) Dough cannot be over proofed.
- 2) Crust temperature must be between 165° and 210° F.
- 3) Steam should be applied for 15 to 180 seconds.
- 4) Steam zone should be a length equivalent to 15 percent of the total travel through the oven.
- 5) Wet saturated steam should be used.
- 6) Boiler pressures should be less than 15 psig.
- 7) Steam injector pressures should be between 2 to 5 psig.

Bread and roll oven production, typically are dictated by the recipe established by the baker. Proper formulation combined with properly conditioned steam and burner management will provide the baker with high quality gloss and avoid unnecessary cracking.

Regarding burner management, the objective in the oven steam zone is to allow the steam to condense on the cool surface of the dough, giving up its latent heat of vaporization and providing moisture to interact with the starches; thus creating the gelatin paste that will result in the desired gloss surface crust. If condensation is the objective, it therefore follows that burners should be turned off when steam is being applied to the product.

So, how do you get the correct steam conditions for your bake? It all starts with the steam system design.

## **Boiler**

First, boiler sizing is based on how much steam will be needed. Boilers are sized based on 1 to 1¼ boiler horsepower per 100 lbs. of dough. For example, if you are planning to process 10,000 lbs/hr. of dough the boiler would be designed to be 100 to 125 BHp.

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## Piping

While most steaming problems can be traced back to the type of steam, pressure, velocity or application in the oven, improper transmission of the steam from the boiler to the oven can also cause problems at the oven. It's at the system design stage that these variables need to be reviewed and understood to ensure that when the system is installed the baker gets the proper steam in necessary amounts he is expecting.

It's all about providing the correct steam "quality", at the correct time and maintaining proper temperatures in the oven. The baker's expectations for gloss on various breads and rolls, plus the oven layout will influence final design and selection of the boiler and dictate the overall length and configuration of the piping. To minimize steam losses the piping from the boiler to the oven must be designed, installed and insulated in accordance with good engineering standards and practices. Also, a pressure valve reducing station must be inserted to lower the pressure in anticipation of steam being "conditioned" prior to being introduced into the oven.

## Steam Conditioning

The provisions for steam conditioning are critical components of the steaming system design. In addition to reducing the super heat in the steam to provide the required dry saturated steam it often times can compensate for variations in the steam delivered from the boiler. While there are various means of conditioning steam, the most reliable and consistent is through the use of steam conditioning tank. In typical designs a tank with a water bath is used to condition the steam.



In a previous paper John A. Dersch suggested that a better name for the conditioner would be "steam regenerator." If properly designed, it takes high-pressure steam and reduces it to dry saturated steam at the pressure at which the system is being operated. It can also remove slugs of water that may be in the piping near the oven at each start-up. The popular idea that the conditioner loads the steam with water that is subsequently applied to the loaf is incorrect. If dry saturated steam is passed through the tank, it will have no effect on the steam whatsoever.

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The side rods for the tank gauge glass should be installed. Typically, these are shipped as part of the “gauge glass set”.

The availability of consistent, properly conditioned steam at the oven will eliminate it as a variable and allow the baker to determine necessary pressures and amounts of steam for various products to be baked in the oven. The system designer should work with the baker to adjust the system as test bakes are run and the best operating conditions are determined and incorporated in to the product recipe(s).

Banner-Day a leader in bakery oven automation and optimization through its sister company, Joseph M. Day Co. is also recognized for its expertise in combustion and thermal engineering, and installation of boiler systems throughout the state of Michigan.

Building on its combustion and thermal engineering experience Banner-Day can also offer the baker support in their steam conditioning process. Banner-Day is uniquely qualified to marry the needs for steam in the baking process with oven performance and operation.

**Credits:**

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By John A. Dersch with acknowledgement to Dr. Lloyd Brownell & others

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## Appendix

### Saturated Steam Table

PRESSURE			TEMPERATURE °F	ENTHALPY		
AT SEA LEVEL		PSI ABS.		LIQUID	EVAP.	SAT. STEAM
PSIG,	IN. HG. VAC.					
	29.7	0.089	32	0	1076	1076
	25.0	2.41	133	101	1018	1119
	20.0	4.86	161	129	1002	1131
	15.0	7.33	179	147	991	1138
	10.0	9.8	192	160	983	1143
	5.0	12.3	203	171	976	1147
0	0	14.7	212	180	970	1150
2		16.7	218	186	966	1152
4		18.7	224	193	962	1155
6		20.7	230	198	958	1156
8		22.7	235	203	984	1157
10		24.7	240	207	952	1159
15		29.7	250	218	945	1163
20		34.7	259	228	939	1167
25		39.7	267	237	933	1170
30		44.7	274	243	929	1172
35		49.7	280	249	925	1174
40		54.7	287	257	919	1176
50		64.7	298	268	912	1180
60		74.7	307	278	905	1183
70		84.7	316	287	898	1185
80		94.7	324	295	892	1187
90		104.7	331	302	886	1188
100		114.7	338	309	881	1190
125		139.7	353	3.23	869	1192
150		164.7	366	338	857	1195
175		189.7	377	350	847	1197
200		214.7	388	361	838	1199
250		264.7	406	381	820	1201
300		314.7	422	398	804	1202
350		364.7	436	414	789	1203
400		414.7	448	427	777	1204
500		514.7	470	453	751	1204

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