Thin Film Ultra-Violet Sterilization of Liquid Sugar, Using the Aquafine Sterilizer[1]

ROBERT S. GADDIE, ROBERT R. WEST, AND E. G. BENNISON[2]

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Applying the thin film penetration theory of ultra-violet sterilization, considerable success in the sterilization of water has been demonstrated the past few years. Using this knowledge the Aquafine Corporation has designed equipment to pass a film of syrup over an ultra-violet source under extremely turbulent conditions so that theoretically a thin film condition was presented to the radiation for each particle of syrup. The equipment used in the experiments detailed in this report was the Model G-4 Aquafine Liquid Sugar Sterilizer. It contains 4 Westinghouse germicidal lamps 4-G36-T6L, wave length 2537 angstroms.

At the West Jordan plant there was available a 4000-gallon cone-bottom liquid-sugar tank. The outlet at the bottom of the cone was piped with 1½ inch pipe to a positive displacement (Viking) pump which pumped through the sterilizer, up over the top of and back into the tank. Circulation was at the rate of 20 gallons per minute. A sample cock was placed on the suction line to the pump and another on the discharge line from the sterilizer. Yeast and mold counts were made according to the method of the A.B.C.B.

Investigation No. 1

One thousand two hundred gallons of liquid sucrose, 66.5 Brix were placed in the tank and seeded with a variety of yeasts normally found in liquid sugar. The mixture was stirred thoroughly and the yeast count determined to be 900 per 10 grams solids. The circulation through the sterilizer was started; and

Table 1.—Yeast counts, circulated liquid sucrose, 20 GPM, single sterilizer.

Time elapsed, hours	Yeasts per 10 gm solids	
	Before sterilizers	After sterilizers
0	900	152
2	104	25
4	29	6
6	8	0

Average kill per pass — approximately 80%.

[1] Aquafine Corporation, 1230 Sunset Boulevard, Los Angeles 26, California.

[2] Respectively, General Chemist; Head Chemist, General Laboratory; and Chemist, West Jordan Factory; Utan-Idaho Sugar Company, Salt Lake City, Utah.

samples were taken for plating each 2 hours from the intake of the pump and from the discharge of the sterilizer. Results are shown in Table 1.

Investigation No. 2

The same 1200 gallons of liquid sucrose were used in the second experiment except that this time they were seeded with a variety of molds commonly found in liquid sugar. The mold count after thorough mixing was 6500 per 10 grams solids, and it was estimated that 1 or 2% of this count was yeasts. Circulation was at 20 gallons per minute, and samples were taken at 0, 2, 4, 12, and 20 hours. Results are shown in Table 2.

Table 2.—Mold counts, circulated liquid sucrose, 20 GPM, single sterilizer.

Time elapsed, hours	Molds per 10 gm solids	
	Before sterilizer	After sterilizer
0	6500	3100
2	3200	950
4	800	400
12	51	36
20	7	5

Average kill per pass — approximately 40%.

Experiment No. 2 confirms what has been found in previous laboratory investigations, that mold spores are considerably more resistant to ultra-violet radiation than yeasts.

Investigation No. 3

As a result of the first two investigations, another Aquafine G-4 unit was purchased and piped in series with the first one. Another batch of 1200 gallons of liquid sucrose was pumped to the tank and seeded with sufficient yeasts to grossly contaminate it. After stirring, the yeast count was determined to be

Table 3.—Yeast counts, circulated liquid sucrose 20 GPM, two sterilizers in series.

Time elapsed, hours	Yeasts per 10 gm solids	
	Before sterilizer	After sterilizer
0	14,400	9
1	5,150	6
2	3,200	1
3	1,200	2
4	640	3
5	175	3
6	73	2
7	32	0
8	9	0

Average kill per pass — approximately 99.9%.

14,400 per 10 grams solids with perhaps 1 or 2% of these being molds. The liquid was again circulated at 20 gallons per minute except that this time it passed through 2 sterilizers in series. Samples before and after the sterilizers were taken each hour for 8 consecutive hours. Results are shown in Table 3.

Liquid Sucrose – Corn Syrup Blends

From the standpoint of the control of micro-organisms, the most difficult of the liquid sweeteners to produce, transport, and store are the liquid sugar—corn syrup blends. If they are subjected to sterilizing temperatures for any length of time, they darken badly. Thin film regenerative heat pasteurizers are effective but to get a practical through-put capacity, are expensive. The ultra-violet sterilizers are economical, easy to install, and with the aid of hoses, they may be made portable. In view of this, it was decided to try these units on blends to determine if one pass at 20 gallons per minute would reduce the yeast and mold count to some practical concentration. Two Aquafine G-4 units were purchased for the Toppenish plant. Here all types of blends are produced, usually in 4500-gallon batches. In installing the two units because the piping was simpler, the factory installed them in parallel on the theory that 20 gallons per minute from the pump giving 10 gallons per minute through each sterilizer would effect the same kill as if they had been connected in series. This did not work out as expected as shown in Table 4 for several representative batches.

Table 4.—Yeast and mold counts, 75-25 liquid sucrose — corn syrup blend, two sterilizers in parallel, 10 GPM through each, single pass.

Before sterilizers		After sterilizers	
Yeasts	Molds	Yeasts	Molds
632	156	510	162
728	54	400	22
872	60	440	8
320	40	272	36
834	110	688	74

Table 5.—Yeast and mold counts, 75-25 liquid sucrose—corn syrup blend, two sterilizers in series, 20 GPM, single pass.

Before sterilizers		After sterilizers	
Yeasts	Molds	Yeasts	Molds
752	120	92	52
484	10	36	0
472	36	0	0
664	12	68	8
872	8	148	0
468	6	54	4

The two units were then piped in series with results shown in Table 5 for several representative batches.

Summary

In the first three investigations the liquid sucrose was circulated out of the tank, through the sterilizer, and back into the tank. Theoretically, the micro-organism count in the tank will be zero only after infinite circulation time. However, results indicate that the following conclusions may be safely drawn.

At a circulation rate of 20 GPM through a single G-4 Aquafine unit operating at normal radiation level, 6 volume throughputs of the 1200 gallons of liquid sugar killed sufficient yeasts in a heavily contaminated liquid sucrose to bring it within Bottler's Standards for yeasts.

At a circulation rate of 20 GPM through a single G-4 Aquafine unit. the 1200 gallons of liquid sucrose grossly contaminated with molds required 12 to 20 volume through-puts to bring it within the limits of Bottler's Standards for molds.

At a pumping rate of 20 GPM of grossly yeast contaminated liquid sucrose through two Aquafine G-4 units in series. a single pass will produce an effluent meeting Bottler's Standards for yeasts.

It was concluded from the results shown in Tables 4 and 5 on liquid sucrose—corn syrup blends that 10 GPM did not result in sufficient turbulence through the sterilizer to produce the thin film condition necessary for ultra-violet radiation sterilization. At 20 GPM and with two sterilizers in series, sufficient kill of micro-organisms could be obtained in a single pass to produce a blend microbiologically suitable for most blend users.