THE CLEANING OF GLASS PIPING IN DAIRY PLANTS*

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The purpose of this study was to determine the relative efficiency of various chemical compounds used to clean permanently installed glass milk lines. Nine different commercial alkaline cleaners and four acid cleaners were selected.

To evaluate the effectiveness of each selected cleaner, a continuous thirty-day test was made at two dairy plants.

For purposes of comparison between physical (180°F hot water) and chemical sanitization, a study of some of the more commonly used chemical germicidal agents was included.

The nine commercial alkaline cleaners adequately cleaned Pyrex brand glass pipe but all quaternary-ammonium compounds used in this study were unsatisfactory either as cleaners or sanitizers.

Review of Preliminary Studies

The October 1950 issue of *Food Industries* reported a preliminary survey of the use of Pyrex brand glass piping in fluid milk plants. The results of this survey indicated that Pyrex brand glass piping might have a real place in dairy manufacturing plants and that it merited more closely controlled research in cleaning methods and costs.

At first many dairymen interested in adopting glass piping met with opposition from health authorities to the in-place cleaning of the pipe. These objections arose from fear of improper sanitation and because of the lack of scientific data as to soil and bacterial removal obtained by the various in-place cleaning methods; such objections were difficult to refute.

In some cases objections were based on local health regulations which required that sanitary pipe be disassembled daily for cleaning. In other instances, although the law did not explicitly require daily disassembly, the sanitarians insisted upon this procedure.

The need for scientific data relating to the sanitary condition of glass piping cleaned in place was made evident by requests from health authorities as well as from dairy plant owners and operators. Thus a study was undertaken at Cornell University in June of 1949 to determine the sanitary condition of glass piping which is cleaned in place by the recirculation of a cleaning solution, as compared to stainless steel sanitary pipe which has been dismantled, cleaned, and reassembled after each day's operation.

In carrying out this study, two glass-pipe lines were permanently installed at the Cornell University dairy plant at Ithaca, New York, and two were installed at the Geneva Milk Company plant at Geneva, New York. The cleaning and sanitizing of these two lines was done under actual plant operating conditions for a period of nine months.

The report of the results of the Cornell study, which includes the four lines mentioned above and several other glass line installations from other dairy plants, was made by Fleischman *et al.*[1,2] in 1950. The conclusions of the authors may be summarized as follows:

1. Pyrex glass-pipe cleaned in place can be kept bacteriologically as clean or cleaner than stainless steel sanitary pipe cleaned in the usual manner.

2. Pyrex brand glass is advantageous in that the plant operator can see visible deposits which might appear in milk pipelines, and he can also see if they have been cleaned.

3. The data indicated that there was no bacterial build-up at the gasketed joints of glass pipe-lines which were in use for nine months at Cornell and Geneva and for over two years in most of the plants surveyed.

4. The results showed that the stainless steel adaptors, which rigidly hold each end of the glass and which are cleaned in place, are no more a source of contamination of milk than is any other stainless steel pipe in the plant.

5. Glass pipe caused no measurable increase in the bacterial count of milk passing through it.

It is noteworthy that the results of the first nine months of investi-

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gation at Cornell closely parallel the findings of Dr. A. C. Fay and his associates at H. P. Hood & Sons Company to Boston, Massachusetts.

Dr. Fay has had an excellent opportunity to become familiar with all aspects of the care, sanitation, and use of glass lines, since the Hood Company has been using glass pipe in increasing amounts since 1944. They now have over one-half a mile of Pyrex brand glass piping in their Boston plant. This glass piping has been in continuous service for transporting raw milk, hot milk, and cold pasteurized milk.

In a paper given at the University of Illinois, January 1950. Dr. Fay[3] reported on swab tests* and rinse counts** that were made periodically by the research department of H. P. Hood & Sons Company on the glass elbows used in their many lines. Dr. Fay summarized these data as follows:

Swab Test*

"1. There are no significant differences between the counts on the pasturized and raw milk lines.

2. Four hundred eighty-four swab samples or 26% showed no growth.

3. One thousand six hundred swab samples or 86% showed plates with not over two colonies each (within the limits of experimental error).

4. One thousand eight hundred and two swab samples or 96.9% showed plates with not over 5 colonies each.

5. Only 58 swab samples or 3.1% showed more than 5 colonies each."

Rinse counts**

"1. Sixty out of 323 samples or 18.6% showed no growth.

2. One hundred seventy-eight out of 323 samples or 55.1% showed not over one colony each.

3. Two hundred fifty-six out of 323 samples or 79.2% showed no more than two colonies each, which is within the limits of experimental error.

4. Three hundred three out of 323 samples or 93.8% showed not over 5 colonies each.

5. Only 20 samples or 6.2% showed more than 5 colonies per plate."

In addition to the investigations at Cornell University and at the research laboratory of the H. P. Hood & Sons Company, J. J. Sheuring and H. B. Henderson[4] have issued a preliminary report giving the results of a study of the sanitation of a glass raw milk line at the University of Georgia. Although the results of the rinse counts of these two workers are not directly comparable with Dr. Fay's work because of different techniques employed***, the Georgia workers' investigations represent an interesting aspect of glass-pipe research not included in any of the reports previously cited. At the October 1950 meeting of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS at Atlantic City, New Jersey, Dr. Sheuring made the following statements:

"1. Glass pipes will easily withstand sudden changes of temperature from 40°F. to 130°F. Higher temperatures have been used for wash water in some instances.

2. The glass pipes were not completely disassembled for eighteen months, when the gaskets were removed in order to show them at this meeting. Data are given on page 12 that indicate the glass pipes can be washed and sanitized effectively by washing with a solution of trisodium phosphate and sterilizing with chlorine.

3. After eighteen months of use, no glass pipes have been broken and no replacements have been necessary.

4. One set of sulfur-free rubber gaskets were used for eighteen months. No trouble was encountered at any time with leaky gaskets. No evidence was obtained that indicated than any seepage occurred between the gaskets and the glass.

5. Glass pipes are certainly adaptable for receiving cold milk in the modern dairy.

6. The expense of installing glass pipes is less than stainless steel. The labor involved in washing and sterilizing the pipes in almost negligible.

7. In this study no breakage has yet occurred so the replacement factor has been insignificant.

8. Glass pipes should be so arranged, especially in the small dairy, that a closed circuit is obtained for washing and sterilizing.

9. The longest pipe in the installation does not exceed ten feet in length. Short pipes are satisfactory for use in small dairies.

10. Continued washing and sterilizing of the pipes, as used in this study, do not discolorize the glass pipes.

11. After eighteen months of use, practically no milkstone exists on the glass pipe."

CLEANING COMPOUND RESEARCH

While the results of these initial investigations represent an important contribution, their main effect has been to stimulate interest in the further use of glass pipe throughout the dairy industry. This interest has raised many questions

*The glass elbows were removed and usually six swab samples were taken, three swabs from each of the two ends of the elbow. The swabs were rinsed in 10 cc of isotonic salt solution. One cc of this sample was plated.

**After rinsing the glass elbows with 100 cc of sterile water, 1 cc of the rinse water was plated.

***In the Georgia study, 10 gallons of sterile water were circulated through the glass line after sanitization. This water was then plated to determine the bacterial count per cc of water after circulation.

left unanswered by the aforementioned investigations. In an attempt to solve some of these problems, it was decided to continue and expand the Cornell investigation.

The first portion of this study was set up to determine the relative efficiency of various chemical mixtures used to clean permanently installed glass milk-lines. Since alkaline cleaners are less expensive and more commonly used in the dairy industry than are acid cleaners, the major portion of the work was done with the alkaline products. Nine different commercial alkaline cleaners and four acid cleaners were selected for the study. They varied considerably in composition but may be considered to be representative of many of the better commercial products now on the market.

Since water hardness exerts an influence on the action of cleaners, two milk plants using water of different hardnesses were selected for the purpose of this study. One was the milk plant at Cornell University with a water supply of approximately five grains per gallon hardness, and the other the Geneva Milk Company plant at Geneva, New York, with a water supply of between 14 and 17 grains per gallon hardness.

To evaluate the effectiveness of each selected cleaner, a continuous 30-day test was made at both plants on each of six of the alkaline cleaners, while the remaining three alkaline and the four acid cleaners were used at one of these plants only, with each test being conducted for the same period of time. The tests of the alkaline products were made on 1 1/2-inch glass pipe lines, transporting both raw and pasteurized milk; whereas, the acid products were used to clean a 1 1/2-inch glass holding tube on a high-temperature short-time pasteurizer.

(The velocity at which the cleaning solutions were circulated in these lines ranged from one foot per second to 10 feet per second.)

The cleaning procedure used for testing the alkaline products was as follows:

1. The system was rinsed with water at 100°F to 110°F until the water flowed clear.

2. Valves and fittings were brushed with cleaner solution.

3. The alkaline cleaning solution was circulated (at the concentration recommended by the manufacturer) for 10 to 15 minutes at 130°F to 150°F.

4. The cleaning solution was rinsed from the system with water at 65°F to 100°F until this rinse water flowed clear.

This procedure is the same as that recommended by the glass manufacturer with but one notable exception in step three. It is normally recommended that a sponge —made from natural or synthetic material and of a size ranging from 2 1/2 to 3 times the diameter of the pipe to be cleaned—should be pumped through the pipe line twice during the circulation of the cleaning solution. This step in the cleaning procedure was intentionally omitted to facilitate observations on the ability of each cleaning compound to remove visible soil from the line under study.

The following cleaning procedure was used for testing the acid products on the glass holding tube of the high-temperature short-time pasteurizer.

1. The machine was flushed with cold water.

2. Valves and fittings were brushed with the acid solution.

3. The acid cleaner was circulated (at the concentration recommended by the manufacturer) for 30 minutes at 140°F to 160°F.

4. The machine was flushed with hot water at 160°F for 5 minutes.

5. Alkaline cleaning solution at a concentration of 2 pounds to 25 gallons of water at 140°F to 160°F was recirculated for 20 minutes.

6. The unit was flushed with cold water.

7. Bactericidal solution was circulated through the machine for 20 minutes.

8. The machine and holding tube were drained.

In addition to the alkaline and acid cleaners, three quaternary-ammonium cleaner-sanitizers were tested to determine their relative cleaning efficiencies. It was originally intended to study each of these for a 30-day period but this became impossible because of the excessive surface film which was built up inside the glass pipe line and, as a consequence, the period had to be shortened to 15 days.

At regular intervals during the test period of cleaning with each product, the lines were examined for visible soil, milkstone, or other deposits on both the inner surface of the glass tubing and on the rubber interface gaskets between each section of tubing. The first method of examination tried was the use of an ultraviolet light emitting a wave-length of 3660A° which was directed into the open end of the glass tubing. Milkstone, if present, should fluoresce when exposed to this light. This method was not satisfactory because the light could not be directed against the inner surface of the pipe, and thus visual inspection was relied upon to detect any film build-up.

To prevent any carry-over of milkstone or other soil on the inner surface of the glass from one 30-day test period to the next, an acid cleaner was used in place of the alkaline cleaner for two days before testing a new material. During this treatment a sponge was circulated with the acid cleaner.

Following the cleaning and sanitizing of the milk lines, swab samples were taken from the inside surface of the glass and interface gaskets, and plated to determine the total bacterial and the coliform counts. The swabbing technique, buffer solution, and media used have been previously described by the authors,[1] with the exception that when bacterial counts were to be obtained from lines sanitized with the hypochlorite agents, the buffer solution was modified by the addition of 0.5 gram of sodium thiosulphate per liter of buffer. This served to counteract the residual chlorine which might be picked up by the swab from the glass surface.

STANDARDS

Before any appraisal could be made as to what constituted satisfactory sanitization some arbitrary standard was needed. It is generally agreed that a milk container is satisfactorily sanitized when it does not contain more than one organism per milliliter of content. This was adopted as the standard for satisfactory sanitization in this study.

The area swabbed was approximately one inch long for each pipe size studied. The volume in milliliters of the pipe included for each swab was calculated from the pipe diameter. This milliliter figure was used as a standard and the figures are shown in table 1.

TABLE 1 — SUGGESTED STANDARDS FOR SATISFACTORY SANITIZATION OF GLASS PIPE LINES

Pipe size	Bacteria per inch swabbed
1"	13
1 1/2"	30
2"	50
2 1/2"	80
3"	115
4"	200

Most of the criticism of the inplace cleaning of glass lines has been directed toward the rubber interface gaskets which is used when two sections of glass are fastened together. To provide a more adequate analysis of the sanitization of glass lines, one swab sample was obtained from the gasket for each swab taken from the glass. In reporting the data, therefore, if the glass plus the adjacent gasket had a total count above that of the standard, *both* samples were reported as *above* standard. By using this method of reporting the data, the point was most susceptible to contamination, the gasket, was given equal weight with the glass line to which it was adjacent. Thus even though the swab obtained from the glass was sterile, if the swab obtained from the gasket was above the standard, both samples were reported as being above standard.

Swab samples were obtained from stainless steel sanitary pipe both at Cornell and Geneva where the pipe had been disassembled, cleaned, reassembled, and sanitized, according to the usual procedures. Such samples provided a basis for comparison between the two types of sanitary piping.

Additional swab samples were obtained from the stainless steel adaptors which fasten securely each end of the glass line. These adaptors are short sections of stainless steel sanitary pipe, and are cleaned in place by the same methods used on the glass. This provided a limited comparison between the sanitizing of permanently installed glass piping and permanently installed stainless steel sanitary piping.

EXPERIMENTAL RESULTS AND DISCUSSION

Cleaning Compounds

Although the nine alkaline cleaners varied widely in composition, no differences in their cleaning action or efficiency were noted during the course of this experiment. There was no case of any milkstone, film, or other visible soil deposits built up on the glass lines during the 30-day period in which each compound was used.

The four acid cleaners were used to clean a 1 1/2-inch glass holding tube on a high-temperature short-time pasteurizer. This glass holding tube was never dismantled except for inspection during the experiment. The glass, cleaned according to the procedure outlined previously, appeared clear and bright at all times regardless of the acid cleaner used.

Experimental Procedure

The original work by Fleischman *et al.*[2] showed that glass milk lines can be satisfactorily sanitized by the recirculation of hot water (above 185°F) or the flowing of steam through these lines for 5 minutes. For purposes of comparison between physical and chemical sanitization, a study of some of the more commonly used chemical agents was included.

For this phase of the study, three hypochlorite compounds and four quaternary-ammonium compounds were selected. Two types of quaternary-ammonium compounds were employed. The first was a straight aqueous solution used solely as a sanitizing agent, and the second was a group of three quaternary-ammonium detergent sanitizers which had been compounded with complex phosphates and other alkalies or with organic acids.

Each of the hypochlorite compounds and one of the quaternary-ammonium compounds circulated for 5 minutes, at 100°F, at a concentration of 200 parts per million. Each of these compounds was tested separately for a continuous 30-day period.

The three quaternary-ammonium detergent-sanitizers were used alone as the sole cleaning and sanitizing agent after the lines had been thoroughly rinsed. These three compounds were the ones tested for the 15-day period, as previously mentioned.

Sanitization

The bacterial counts which were obtained in these studies are shown in table 2. Those from the stainless steel sanitary pipe which was dismantled, cleaned, reassembled, and sanitized with hot water are given in column 1. Column 2 presents

TABLE 2 — RESULTS OF BACTERIAL COUNTS OBTAINED FROM STEEL AND GLASS SANITARY PIPE USING DIFFERENT SANITIZERS

Columns	1	2		3		4		5	
Type of sanitizer used	Hot water	Hot water		200 ppm chlorine (Compound #1)		200 ppm chlorine (Compound #2)		200 ppm chlorine (Compound #3)	
	Stainless steel control samples	Steel adaptors	Glass + gaskets	Steel adaptors	Glass + gaskets	Steel adaptors	Glass + gaskets	Steel adaptors	Glass + gaskets
No. of samples	92	132	801	20	90	16	96	16	96
No. of sterile samples	23 (25%)	55 (42%)	225 (28%)	13 (65%)	48 (53%)	9 (56%)	39 (41%)	8 (50%)	33 (34%)
No. of samples above standard	37 (40%)	30 (23%)	24 (3%)	1 (5%)	0 (0%)	4 (25%)	6 (6%)	1 (6%)	3 (3%)
No. of *coli* positive samples	6	2	0	0	0	0	0	0	0

Columns	6		7		8		9	
Type of sanitizer used	200 ppm quaternary ammonium solution (Compound #4)		200 ppm quaternary ammonium solution (Compound #5		200 ppm quaternary ammonium solution (Compound #6)		150 ppm quaternary ammonium solution (Compound #7)	
	Steel adaptors	Glass + gaskets	Steel adaptors	Glass + gaskets	Steel adaptors	Glass + gaskets	Steel adaptors	Glass + gaskets
No. of samples	16	96	34	132	8	48	10	48
No. of sterile samples	12 (71%)	39 (41%)	18 (53%)	45 (34%)	5 (62%)	9 (19%)	2 (20%)	6 (13%)
No. of samples above standard	0	9 (10%)	6 (18%)	24 (18%)	2 (25%)	18 (38%)	4 (40%)	36 (75%)
No. of *coli* positive samples	0	0	1	0	2	14	2	2

the bacterial counts of the glass piping which had been cleaned and sanitized in place with hot water.

It should be noted that although there was only a slight difference in the percentage of sterile samples between the glass and the stainless steel pipe lines, there was a considerable difference in the percentage of samples which had bacterial counts above the standard outlined in table 1. The glass pipe which was cleaned and sanitized showed only 3 percent of the samples above the standard, whereas the stainless steel sanitary pipe which had been dismantled, cleaned, reassembled, and sanitized, according to the usual procedure gave 40 percent of the samples above the standard.

Columns 3, 4, and 5 show the results obtained when three different hypochlorite solutions were used as sanitizing agents. The data in these three columns indicate that there was little or no difference in the germicidal efficiency of the three compounds. When the results are compared with results obtained using heat as the sanitizing agent, there are again only slight differences. This would indicate that either hot water or a 200-parts-per-million solution of hypochlorite will satisfactorily sanitize glass pipe lines.

The results obtained using a quaternary-ammonium sanitizer only (compound #4) are shown in column 6. This compound was used at a 200-parts-per-million concentration after the glass line had been washed with a good alkaline cleaner and thoroughly rinsed. The bacteriological results obtained compare favorably with the results obtained while using either hot water or a 200-parts-per-million hypochlorite solution. From a practical standpoint, however, this compound was unsatisfactory because a film was built up on the inner surface of the pipe and gaskets before the end of the 30-day test period.

The results obtained when using two alkaline detergent-sanitizers (compounds #5 and #6) at a quaternary concentration of 200 parts per million to clean and sanitize the glass lines are given in columns 7 and 8. Not only were the bacterial counts in the glass lines higher in both cases than the counts obtained when other sanitizers were used, but in addition a brownish white film began to build up on the inner surface of the glass after only a few days of use. This became so pronounced after 15 days that the use of the detergent sanitizers was discontinued. This film may, in part, explain the higher bacterial counts.

Dr. P. R. Elliker,[5] of Oregon State College, reported after working with quaternary-ammonium detergent-sanitizers that the brown precipitate which developed might have represented an interaction between the quaternary and the milk proteins. He further reports that the proper rinsing of dairy equipment prevented this precipitate from forming. In line with Dr. Elliker's findings, as soon as the film first appeared on the glass lines, special precautions were taken to have these lines properly rinsed before the detergent-sanitizer was used. This special rinsing had little effect, however, and the precipitate continued to form on the glass surface.

One acid detergent-sanitizer was included in the study, and the results obtained from its use at a concentration of 150 parts per million, according to the recommendation of the manufacturer, are shown in column 9 (compound #7). This compound gave even poorer bacterial counts than the alkaline products, and the formation of the precipitate was just as pronounced.

It is interesting to note that when heat or hypochlorites were used for sanitization, the percentage of samples above the standard was consistently higher for the stainless steel adaptors than for the glass piping. This would indicate that the glass is more readily sanitized by these two media than was the stainless steel. This appears to contradict the findings of Moore,[6] at Illinois, who, when working with both glass and stainless steel sanitary pipes cleaned in place, reported that there was very little difference in the bacterial counts between the surface growth on glass and on stainless steel of different polishes. He reported, however, that some stainless steel sections developed leaky joints due to improper seating of the gaskets which resulted in "numerous milk remnants" being picked up by the swab and causing extremely high counts. His omission of these high-count samples from his tabulation would account for some of the discrepancy between this study and his work.

Since the stainless steel adaptors which are at each end of the glass lines are exposed to the air, there could possibly have been some bacterial contamination from this source which might in part explain some of the differences between the bacterial results on the glass and those on the steel adaptors.

In the trials in which the quaternary-ammonium compounds were used, the stainless steel adaptors had a smaller percentage of samples above standard that was found on the glass. This might be accounted for by the fact that the brown precipitate formation was not so extensive on the steel as on the glass. This would seem to indicate that there is an attraction between the quaternary and the glass causing this precipitation which might not occur between the quaternary and the stainless steel.

SUMMARY AND CONCLUSIONS

1. The nine commercial alkaline cleaners, which are representative of the better cleaners now on the market, adequately cleaned physically and bacteriologically Pyrex brand glass piping when used in accordance with the manufacturers' recommendations.

2. Each of the four acid cleaners studied satisfactorily cleaned the glass holding tube on the high-temperature short-time pasteurizer. These were used in conjunction with an alkaline cleaner.

3. Either water above 185°F or a 200-parts-per-million hypochlorite solution circulated for 5 minutes satisfactorily sanitized Pyrex piping cleaned in place.

4. All quaternary-ammonium compounds used in this study were unsatisfactory either as cleaners or sanitizers as they gave higher bacterial counts than either hot water or hypochlorite solution, and built up films on the inner surface of the glass pipe and gaskets after short periods of use.

5. Glass piping, cleaned and sanitized in place, gave consistently lower bacterial counts than stainless steel sanitary pipe cleaned by daily dismantling, cleaning, reassembling, and sanitizing.

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